

# **Data Management Center Report**

## **Eastern Turkey Seismic Experiment (ETSE): Lithospheric Structure in an Active Continental Collision Zone**

This PASSCAL project was a collaborative, joint research between Turkish and Cornell researchers. Scientists from Kandilli Observatory and Earthquake Research Institute (KOERI), Atatürk University, and Cornell University have all participated in the deployment, servicing and dismantling of the 29 broadband seismic stations in eastern Turkey, from October 1999 to August 2001. Local government officials provided very valuable logistical support for this experiment. We chose sites that allowed for relatively easy station access and offer security from vandals and curious children. In many cases we installed seismometers within government establishments. During the ETSE experiment there was not a single case of vandalism of any of our seismic stations.

In order to ensure maximum data recovery of local, regional, and teleseismic waveforms, we recorded all data as 24 bit continuously at 40 sps (samples per second). Data recorded at 40 sps provided sufficiently high resolution for accurately locating local events as well as analyzing regional wave propagation. Using PASSCAL's 4.1 GByte field disks and the REFTEK 72A's data compression algorithm, we have found that given our rate of data compression we did not need to visit our stations more than once every 4 months. Over 750 Gigabytes of (uncompressed) data were collected in eastern Turkey where, prior to this experiment, no modern seismic stations existed. During the 21 months that the ETSE network was deployed, we recorded approximately 330 teleseismic events.

The network consisted of two main transects: an eastern linear array of twelve stations and a western array of eight stations. The interior of the V shape formed by the transects is filled with nine stations. The average station separation was approximately 50 km for the western line and 30 km for the eastern line. Each broadband station was

equipped with a Streckeisen STS-1 seismometer, a REFTEK 72A recorder with a 4 GB field disk and solar panels, except for station EZRM. A Guralp CMG-3T seismometer was used at station EZRM. An automated network triggering algorithm based on STA (short term averaging) and LTA (long term averaging) was used to detect the events. To set the values of STA, LTA and their ratio, STA/LTA, the aftershocks of the Senkaya earthquake, which occurred in the northeastern corner of the Anatolian plateau in the beginning of the experiment, were used.

Approximately 7500 regional waveforms are also collected from the ETSE stations with varying epicentral distances. We used event locations are obtained from the Preliminary Determination of Epicenters (PDE) monthly catalog and the KOERI catalog. Seismograms were eliminated that had signal to noise ratios less than three and epicentral distances between  $5^{\circ}$  and  $15^{\circ}$ .

The data recorded by this array have greatly improved our knowledge of seismicity in this region by revealing earthquake hypocenters that would otherwise have gone undetected. During the experiment, approximately 10 events per day were detected and a total of 1165 local earthquakes (Fig. 2) were located. Furthermore, two moderate size earthquakes ( $M \approx 5.5$ ) Senkaya and in Lake Van occurred during the deployment of the Eastern Turkey Seismic Experiment (ETSE). The accuracy of the locations were ranked in the two highest quality categories is estimated to be less than 10 km. The results show that seismic activity in Eastern Turkey is higher than previously documented and there were no subcrustal earthquakes beneath the Arabian-Eurasian collision zone or beneath the Anatolian plateau during our deployment. Our complete catalog of seismicity in Eastern Anatolia has provided important information on national earthquake hazards as well as improve our understanding of the current deformational patterns.

Our western traverse crosses a region where it has been well documented that the Anatolian block is escaping westward while in easternmost Turkey it appears GPS data suggest that the crust is being shortened. Receiver function models for our western and

eastern stations located along the Eastern Anatolian Fault suggest that there is no significant crustal root beneath the Anatolian plateau; there exists only a gentle thickening of the crust until the northern Pontide mountains. Furthermore we observed a region of crustal thinning near Lake Van, just north of the Bitlis suture. This unexpected result may be due to a localized crustal delamination event or reflect a lack of horizontal shortening in this portion of the Eurasian-Arabian collision. Analysis of shear wave splitting shows that there is no obvious change in mantle azimuthal anisotropy across the Eastern Anatolian Fault Zone and the Bitlis suture. Comparison with Pn anisotropy and the uniform nature of the shear wave splitting parameters across the entire network are indication that the source of the polarization anisotropy is in the asthenospheric part of the upper-mantle.

Eight papers were published in a special volume of *Geophysical Research Letters* outlining the major results from the ETSE experiment. These series of papers include work on seismology, seismo-tectonics, geochemistry and geology.

#### **Publications Directly Related to ETSE Data and/or results**

- Keskin, M., Magma generation by slab breakoff beneath a subduction-accretion complex: an alternative model for collision-related volcanism in Eastern Anatolia, *Geophysical Research Letters*, 8044, doi:10.1029/2003GL018019., 2003.
- Sengor, A. M. C., Ozeren, S., Zor, E. and Genc, T., East Anatolian high plateau as a mantle-supported, N-S shortened domal structure, *Geophys. Res. Lett.*, 8044, doi:10.1029/2003GL017858., 2003.
- Sandvol, E., Turkelli N., and Barazangi, M., The Eastern Turkey Seismic Experiment: The study of a young continent-continent collision, *Geophysical Research Letters*, 30, 8038, doi:10.1029/2003GL018912, 2003
- Sandvol, E., Turkelli N., Zor,E., Gok R., Bekler, T., Gurbuz,C., Seber, and Barazangi, M., Shear Wave Splitting in a Young Continent-Continent Collision: An Example from Eastern Turkey, *Geophysical Research Letters*, 30, 8041, doi:10.1029/2003GL017390, 2003.
- Zor, E., Sandvol, E., Gurbuz, C., Turkelli, N., Seber, D., and Barazangi, M., The Crustal Structure of the East Anatolian Plateau from Receiver Functions, *Geophysical Research Letters*, 30, 8044, doi:10.1029/2003GL018192., 2003.
- Gok, R., Sandvol, E., Turkelli, N., Seber, D., and Barazangi, M., Sn Attenuation in the Anatolian and Iranian Plateaus and Surrounding Regions, *Geophysical Research Letters*, 30, 8042, doi:10.1029/2003GL018020, 2003.

- Orgulu, G., Ahktar, M., Sandvol, E., and Barazangi, M., The Seismotectonics of the Eastern Anatolian Plateau, *Geophysical Research Letters*, 30, 8040, doi:10.1029/2003GL018258, 2003.
- Turkelli, N., Sandvol, E., Zor, E., Gok, R., Bekler, T., Lazki, A., Karabulut, H., Kuleli, S., Eken, T., Gurbuz, C., Bayraktutan, S., Seber, D., and Barazangi, M., Seismogenic zones in Eastern Turkey *Geophys. Res. Lett.*, 30, 8042, doi:10.1029/2003GL018023, 2003.
- Al-Lazki, A., Sandvol, E., Seber, D., Turkelli, N., Mohamad, R., and Barazangi, M., Tomographic Pn velocity and anisotropy structure beneath the Anatolian plateau (eastern Turkey) and the surrounding regions, *Geophysical Research Letters*, 30, 8040, doi:10.1029/2003GL017391, 2003.
- Gurbuz, C., Turkelli, N., Bekler, T., Gok, R., Sandvol, E., Seber, D., and Barazangi, M. Seismic Event Location Calibration and Attenuation Using the Eastern Turkey Broadband Seismic Network: Analysis of the Agri Dam Explosion *Bul. Seism. Soc. Amer.*, in press, 2004.
- Sandvol, E., Forsythe, D., and Turkelli, N., The three dimensional velocity structure from Rayleigh wave phase velocities for eastern Turkey, in prep., 2004.