

**EXTENSION OF THE CAUCASUS SEISMIC INFORMATION NETWORK STUDY INTO  
CENTRAL ASIA**

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Sponsored by National Nuclear Security Administration

Contract Nos. DE-AC52-04NA25612<sup>1</sup>, DE-AC52-07NA27344<sup>2</sup>, and DE-AC52-04NA25612<sup>3</sup>

**ABSTRACT**

The Central Asian Seismic Research Initiative (CASRI) is an extension of the Caucasus Seismic Information Network (CauSIN). Both projects seek to promote cooperation, transparency, and stability in these highly seismically active regions of strategic interest to the U.S. by working with the countries to improve the monitoring and hazard assessment. Building knowledge bases of geological, geophysical, and seismic information in the respective regions, utilizing modern crustal modeling techniques to create a combined model of the regions, and applying modern hazard assessment techniques will aid these countries in improving their seismic monitoring capacity. The CauSIN project was completed in 2007; the CASRI is currently in its final stages, though work in the area will be continued in a separate project.

Over the past three years, a great deal of tectonic, geologic, geophysical, seismic event catalog, waveform, and phase arrival data from local networks in the CASRI region (Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan) have been collected. The historical catalog contains nearly 11,000 events from 500 AD through the present. The modern seismic catalog (from the digital instrumental period) includes 469 events from 1991 to 2005.

In the past year, a large number of phase arrival time picks have been collected from stations of the local networks in Kazakhstan and Kyrgyzstan. (Uzbekistan and Tajikistan do not currently have operating digital stations.) Kyrgyzstan has a ten-station digital network (KNET) that began operations in September 1991 as the result of a cooperative project sponsored by the Incorporated Research Institutions for Seismology (IRIS) university consortium and the Kyrgyz government. The National Nuclear Center of Republic of Kazakhstan (NNC RK) operates thirteen digital stations that have been brought online in various stages since the summer of 1994. This includes three IRIS monitoring stations and seven arrays, the newest of which was installed in 2004.

The local time pick database from Kazakhstan and Kyrgyzstan includes over 6,000 P phase picks and 2,500 S phase picks from more than 400 events. Following a process similar to that used in the CauSIN project, the local time pick database is combined with time picks from the Engdahl, van der Hilst, and Buland (EHB) database in preparation for a rigorous crustal tomography calculation. Together, these data provide coverage of the seismically active southern portion of the CASRI study region, but almost no coverage in the quiescent shield area to the north. However, explosion events provide some coverage in this gap. Newly digitized waveform data have been received for nuclear tests at the Semipalatinsk test site in Kazakhstan, Lop Nor in China, Pokharan in India, and Chagai in Pakistan, as well as for several peaceful nuclear explosion (PNE) events scattered throughout Turkmenistan, Uzbekistan, Kazakhstan, and southern Russia.

# Report Documentation Page

*Form Approved*  
*OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE <b>SEP 2008</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2008 to 00-00-2008</b>	
4. TITLE AND SUBTITLE <b>Extension of the Caucasus Seismic Information Network Study into Central Asia</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Lawrence Livermore National Laboratory, PO Box 808, Livermore, CA, 94551-0808</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>Proceedings of the 30th Monitoring Research Review: Ground-Based Nuclear Explosion? Monitoring? Technologies, 23-25 Sep 2008, Portsmouth, VA sponsored by the National Nuclear Security Administration (NNSA) and the Air Force Research Laboratory (AFRL)</b>					
14. ABSTRACT <b>see report</b>					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

## **OBJECTIVES**

The primary goal of this project is to develop a database of new waveform data, geology, and active tectonics in the Caucasus and Central Asian regions. With this new database, we will be able to improve earthquake locations and identify potential “ground truth” (GT) events, aiding in the monitoring of these regions of strategic interest to U.S. national security. The dense network, calibration events (mining and quarry blasts), improved models, and better location algorithms (including multiple-event grid search, and double difference) will improve the event locations. Scientists at collaborating countries are very eager to assist with this task, since improved locations will aid in the identification of active faults and help them to improve their hazard assessments and building codes for the region, better protecting public safety and stability for their countries.

With the ground truth events to serve as validation, we will obtain a detailed crust/upper mantle structure in Central Asia, using data from newly installed seismic stations as well as the Global Seismic Network (GSN) and other stations operated as part of the national networks.

## **RESEARCH ACCOMPLISHED**

### **1.0 Local Networks**

Recent meetings with seismologists from the participating CASRI nations have led to the sharing of detailed information about the local networks, most of which have been undergoing a period of recovery and expansion since the breakup of the Soviet Union. Reviews of the full status of the networks in Kazakhstan, Kyrgyzstan, Uzbekistan, and Tajikistan follow.

### **1.1 Kazakhstan**

The NNC RK and the Institute of Seismology have been the main body operating seismic networks in Kazakhstan. The networks of the NNC RK operated nearly continuously throughout the tumultuous early 90s, focusing primarily on meeting treaty monitoring obligation, while the Institute of Seismology was operating mainly analog networks during this period, with a focus on earthquake monitoring. The network included both analog and digital weak-motion stations (KazNET) as well as strong motion instruments.

The main installations of the NNC RK were the Geophysical Observatories at Aktyuinsk, Borovoye, Kurchatov, and Makanchi, which were created during the Soviet times for monitoring worldwide nuclear explosions and passed to the Institute of Geophysical Research at the NNC RK in 1994. At that time, a Joint Seismic Program (JSP) between the NNC RK and IRIS in the U.S. was established, with the goal of making effective use of Kazakhstan’s monitoring capabilities. Eight broadband 3-component stations (AKT, BRV, ZRN, VOS, CHK, KUR, MAK and TLG) equipped with STS-2 and CMG-3 seismometers and IRIS/PASSCAL 16 and 24-bit digital data acquisition systems were installed in July and August 1994, and a unique 24-element Kurchatov seismic “cross array” began operating in October.

Between 1994 and 1996, 3-component broadband IRIS stations were installed at the Borovoye and Kurchatov observatories and in Makanchi, and the Borovoye and Kurchatov arrays received equipment updates. All of these stations are part of the GSN and used in joint experiments with the Lamont-Doherty Earth Observatory of Columbia University in the U.S.

In 1996, Kazakhstan signed the Comprehensive Nuclear-Test-Ban Treaty (CTBT), and five facilities located on Kazakhstan territory were included in the newly created International Monitoring System. These include the Makanchi seismic array (PS23), which is a primary IMS seismic station, seismic arrays Borovoye (AS057), Kurchatov (AS058), and the Aktyubinsk 3-component seismic station (AS059), which are auxiliary seismic network stations, and the Aktyubinsk infrasound station (IS31).

Since April 1997 NNC RK had carried out several projects which have expanded their network, continuing to add modern acquisition equipment and satellite communication systems to existing stations and adding seismic arrays such as those in Makanchi, Borovoye, and Makanchi which operate as part of the IMS.

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In sum, NNC RK now operates thirteen digital stations (see Figure 1A), which include 3 IRIS monitoring stations and 7 arrays. NNC RK sends data out to several groups, including the IDC, USA NDC, IRIS, EMSC, ISC, the Institute of Seismology of Kazakhstan, GS RAS, NORSEAR, and SEA/DASE. (More information is available at <http://www.kndc.kz>). Additionally, the Institute of Seismology is in the process of upgrading their weak-motion network, adding digital three-component weak-motion and strong-motion stations for earthquake monitoring.

### 1.2 Kyrgyzstan

Kyrgyzstan operates a 10-station broadband seismic network called KNET, which became operational in September 1991 (see Figure 1). So far in its lifetime, with IRIS sponsorship and JSP funding, it has survived the economic and political turbulence from the breakup of the former Soviet Union and the formation of the Republic of Kyrgyzstan, as well as the 19 August 1992, magnitude-7.4 Suusamyr earthquake, located under the network station Almayashu (AML). KNET is operated by the Kyrgyz Institute of Seismology (KIS) and the Institute of High Temperature Physics of the Russian Academy of Sciences (IVTAN). IRIS participants in this project have included the University of California at San Diego, Indiana University, Rennselear Polytechnic Institute, and the University of Colorado. The University of California San Diego had responsibility for collecting and processing KNET data most recently in 2002.

KNET utilizes Streckeisen STS-2 sensors with PASSCAL dataloggers, which are combined with advanced digital telemetry and data processing techniques to provide high-dynamic-range (24-bit), broadband (0.008–50 Hz.) seismic data. The geometry of the network was dictated by the need to maximize earthquake monitoring capability within line-of-sight telemetry constraints. Since this network has broadband sensors, it may also be used as a long-period array, which will enhance signals with apparent wavelengths in the range of 10 to 100 kilometers.

In addition to the triggered data set, over five years of continuous network data are presently available. All data, along with several technical reports, are available through the IRIS Data Management Center in Seattle (<http://eqinfo.ucsd.edu/deployments/knet.php>).

### 1.3 Uzbekistan

The seismic network of the Institute of Seismology, Academy of Sciences, Uzbekistan, has been actively pursuing sources of funding to upgrade its analog seismic to digital or to install all new stations. In 2002, China installed 5 broadband digital stations in Uzbekistan, but it has been very difficult for the country to utilize the data received, and today none of the stations are operational. At the present time, therefore, there are no operational digital stations.

### 1.4 Tajikistan

Tajikistan once operated a network of 49 analog stations, but the civil war of 1992 resulted in a great deal of damage, and much of the seismic data collected in the previous several decades was lost. At present, the network still does not function, but efforts are underway to recover existing hardware and upgrade it to digital where possible (<http://www.smnt.tj>). Working with a group of Swiss seismologists, they have recently added several new digital seismic stations; they have some records from the last three years only.

## 2.0 Seismic Data: Event Catalogs

The past year has seen addition to our database of the earthquake catalog from CASRI scientists. The catalog is shown in Figure 2, split into events in the historical period before 1922, when the Soviet era began; the Soviet era; and the years since 1991, after the Soviet era.

### **2.1 Seismic Data: Phase Arrivals**

Phase arrival tables have been received from CASRI participants (Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan). Figure 3 shows that ray paths are focused in the southern portion of the study area, since very little seismic activity takes place in the stable shield to the north. P wave paths, shown in the top figure, extend toward the Caspian Sea, while S wave paths in the western part of the study region are sparser.

These data are being combined with time picks from the EHB database in preparation for tomography studies.

### **2.2 Seismic Data: Nuclear Explosions**

Another aspect of the data collected in the CASRI project is time pick and waveform data from explosion events in central Asia, specifically waveform data not previously available. Figure 3 shows events for which waveform data have been received. These include nuclear tests at the Semipalatinsk test site in Kazakhstan, Lop Nor in China, Pokharan in India, and Chagai in Pakistan, and several peaceful nuclear explosion (PNE) events scattered throughout Turkmenistan, Uzbekistan, Kazakhstan, and southern Russia. Data from the PNE events will be especially helpful to the tomography studies discussed in the next section, since they provide ray paths in the seismically inactive stable shield region of northern Kazakhstan.

Data from several nuclear explosions, shown in Figure 4, provide ray paths in the seismically quiescent region of northern Kazakhstan and provide ground truth in tomography studies. Figures 5 and 6 show waveforms for a nuclear explosion at the Semipalatinsk Test Site in northeast Kazakhstan and for a peaceful nuclear explosion (PNE) in southern Russia.

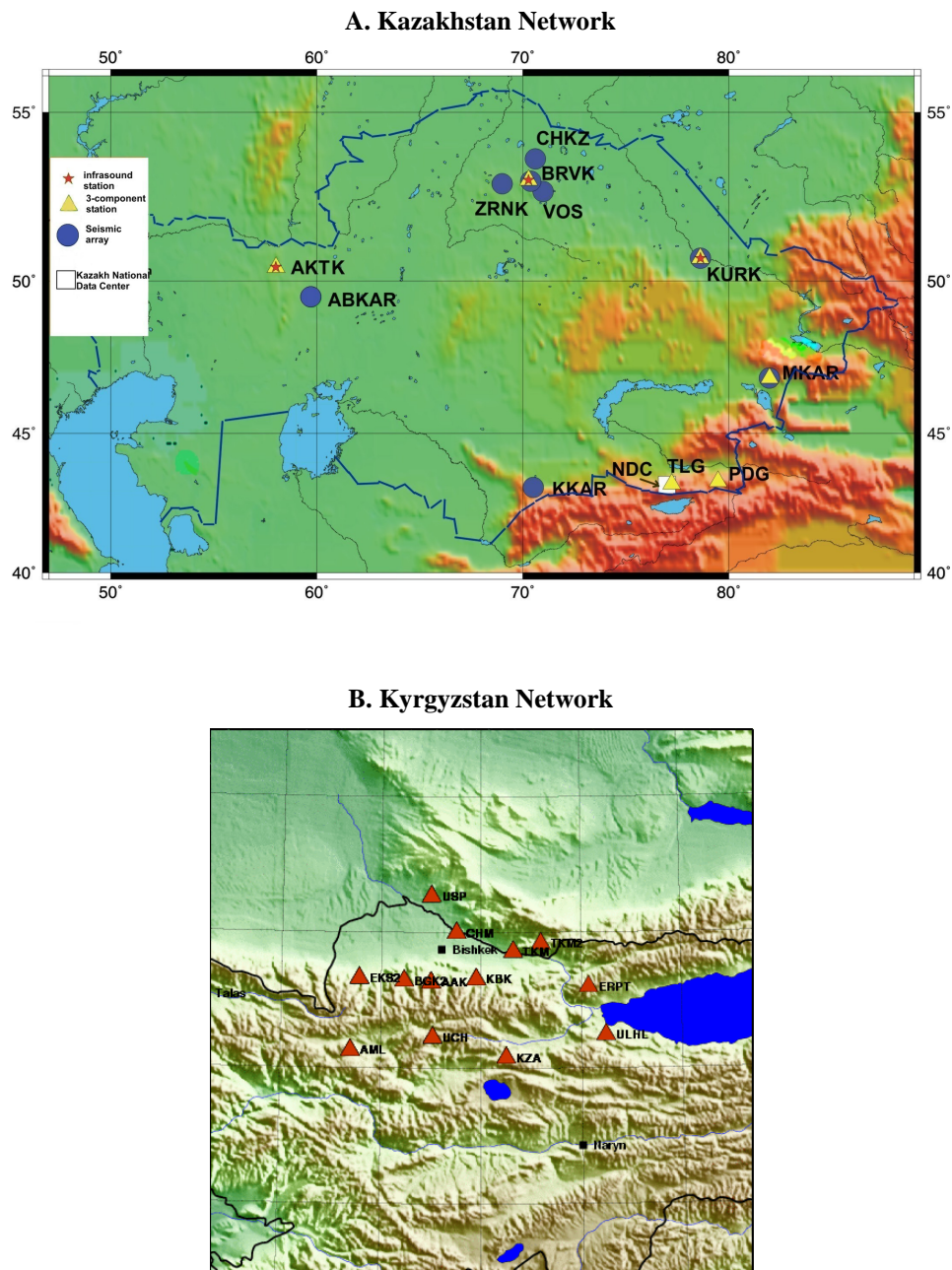
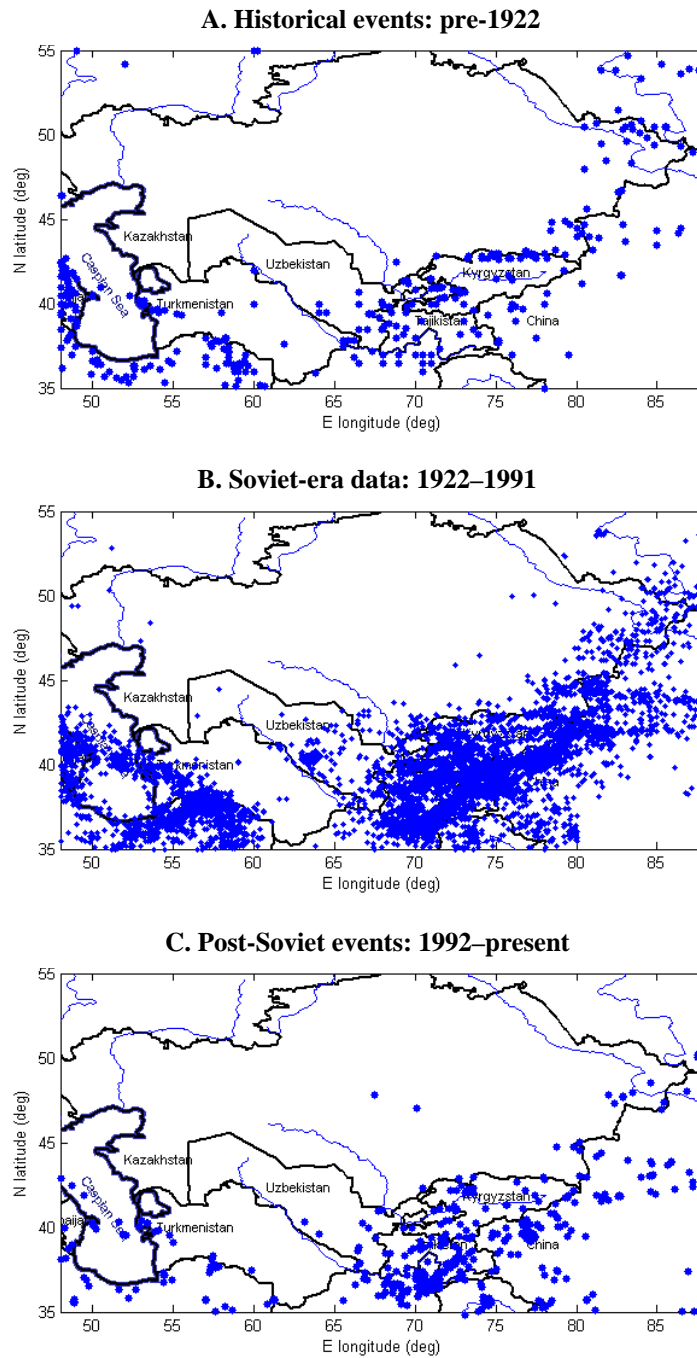
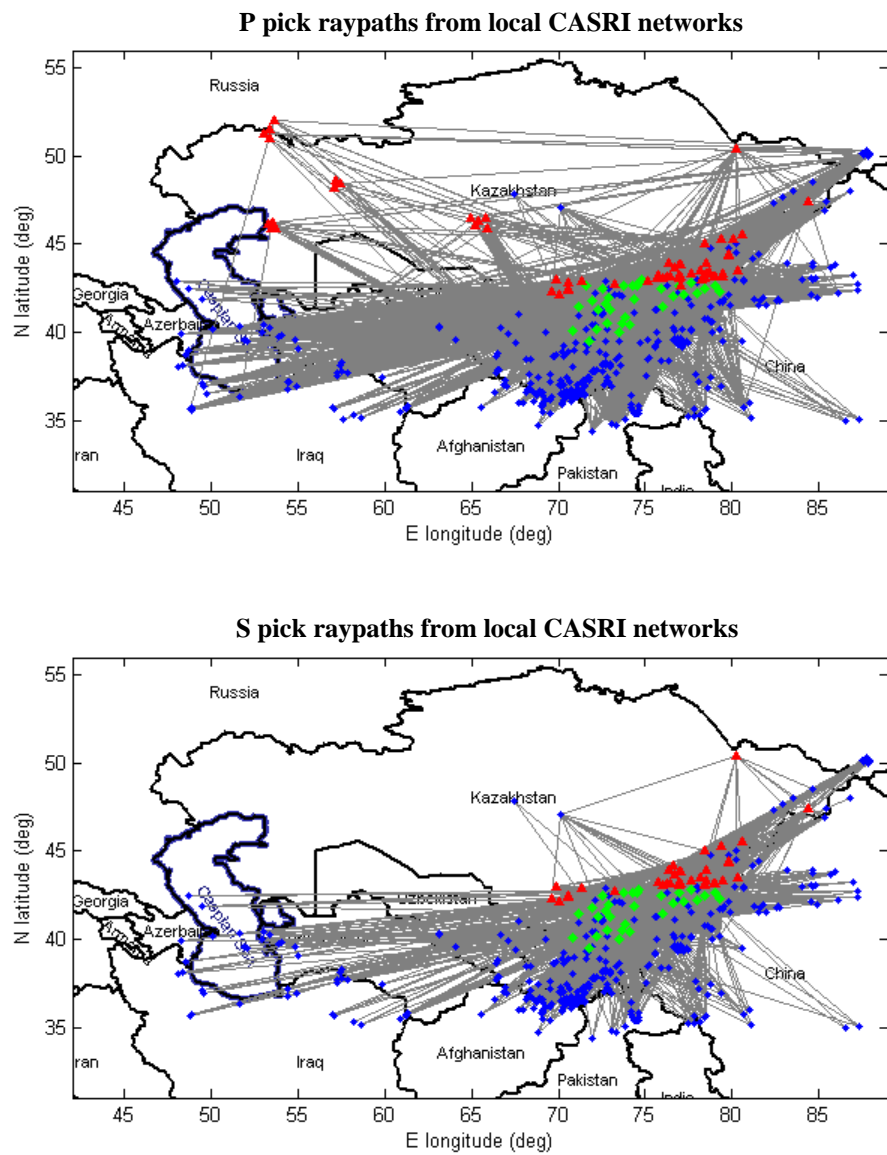


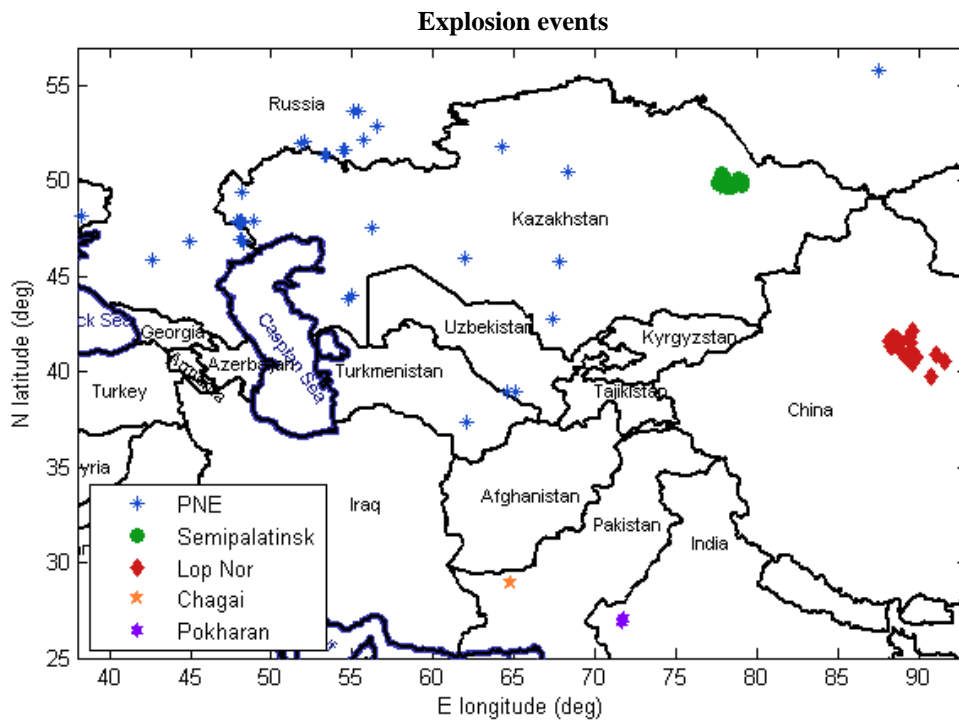
Figure 1. Maps of local seismic networks discussed in sections 1.1 and 1.2.



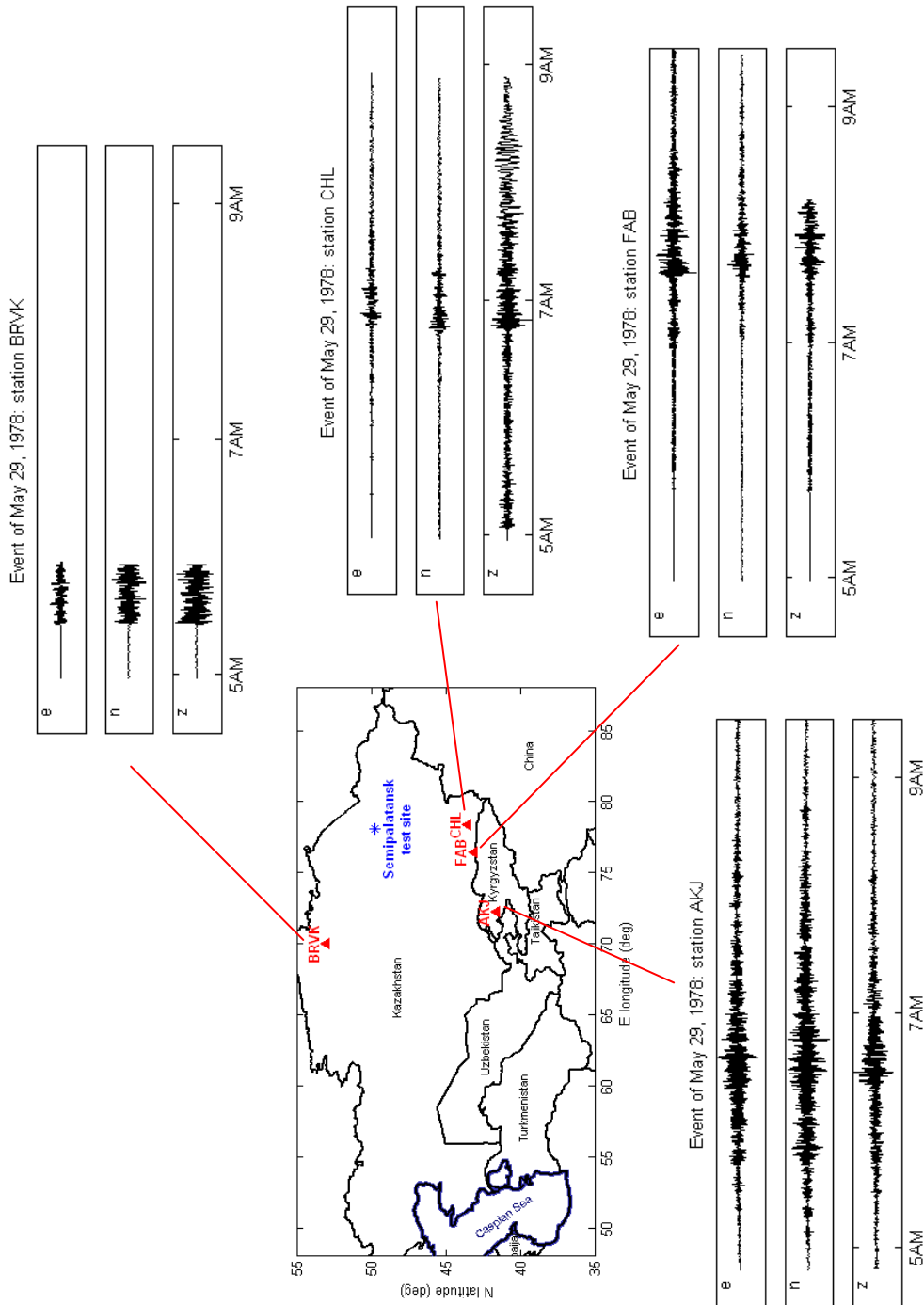
**Figure 2. Event catalog, split into three eras: pre-Soviet Union, including events back to 2000 BC; the Soviet era; and 1992–present.**



**Figure 3. Ray paths to stations in Central Asia from local and regional earthquakes for which arrival times are available.**



**Figure 4. Event locations for explosion data collected during the CASRI project. Data from peaceful nuclear explosion (PNEs) will provide ray paths in the seismically quiet north Kazakhstan region.**



**Figure 5.** A nuclear test carried out at the Semipalatansk test site on May 29, 1978, recorded at four stations in Kazakhstan and Kyrgyzstan. The data provide ground truth in tomographic studies of the crust, since the exact position of the source is known.

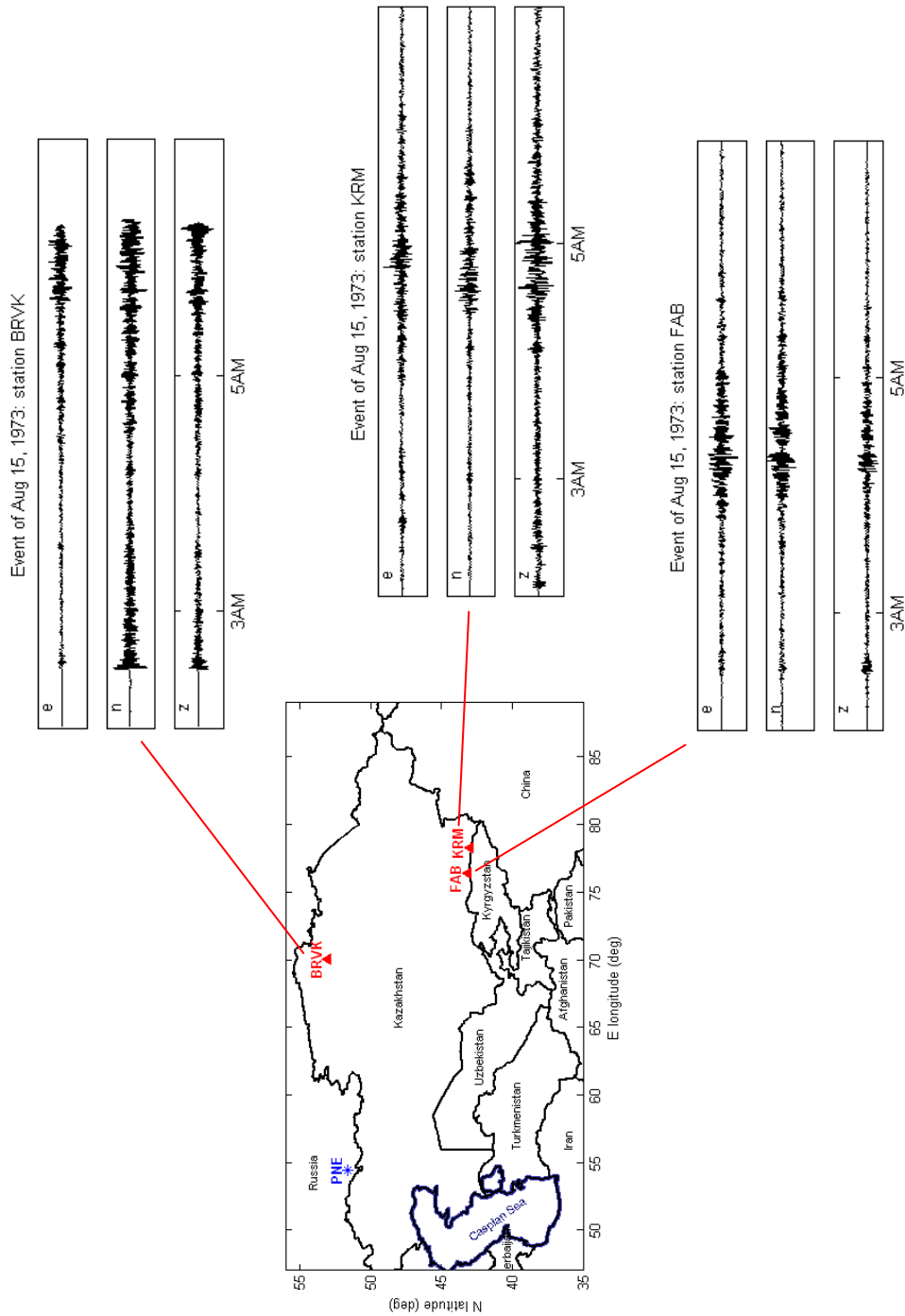


Figure 6. A peaceful nuclear event (PNE) carried out in southern Russian on August 15, 1973, recorded at three stations in Kazakhstan. In addition to providing ground truth, PNE data include ray paths in the seismically quiescent area of northern Kazakhstan.