CALIBRATION DATA FOR PS38 IN THE CENTRAL ARABIAN PENINSULA

Arthur J. Rodgers[1] and Abdullah M. S. Al-Amri[2]

Lawrence Livermore National Laboratory,[1]
Seismic Studies Center and Geology Department, King Saud University[2]

Sponsored by National Nuclear Security Administration
Office of Nonproliferation Research and Engineering
Office of Defense Nuclear Nonproliferation

Contract No. W-7405-ENG-48[1] and DE-FC03-01SF22418[2]

ABSTRACT

In order to improve monitoring of explosions in the Middle East, we are collecting calibration waveform data near the site of primary seismic array PS38 in central Saudi Arabia. This site is located on the Arabian Shield near the town of Halban and was host to a station deployed by the US Department of Energy-funded University of California at San Diego Broadband Deployment 1995-1997 (Vernon and Berger, 1998). Noise surveys found this site to be very quiet (Mellors, 1998; Al-Amri *et al*., 1999). We re-occupied the same vault in January 2002 with a broadband Guralp CMG-3T three-component seismometer. Data are recorded to a REFTEK 72A 24-bit digitizer and saved on a 1-Gigabyte SCSI (small computer system interface) field disk. King Saud University Seismic Studies Center personnel service the station every 6-8 weeks. Data from this station will be made available for analysis as a surrogate station for the planned International Monitoring System (IMS) primary seismic array PS38. This station has been sited and a noise survey has been performed by the King Abdulaziz City for Science and Technology (KACST), although the installation and certification dates are not yet known. As part of a separate effort, we are performing analysis of broadband data recorded by our station and others in Saudi Arabia to support location and identification efforts.

OBJECTIVE

The objective of this project is to collect raw waveform data for empirical calibration of the International Monitoring System (IMS) primary seismic array (PS38) planned near the town of Halban in central Saudi Arabia.

RESEARCH ACCOMPLISHED

Introduction

The IMS of the Comprehensive Nuclear Test-Ban Treaty Organization (CTBT0) will rely on seismic stations and arrays to monitor nuclear explosions. An IMS primary seismic array is being planned near the town of Halban on the Arabian Shield in central Saudi Arabia. Figure 1 shows a map of the Middle East with existing and planned IMS seismic stations.

A Department of Energy (DOE) Research Opportunity Announcement (ROA) project was funded to collect calibration data for explosion monitoring of the Arabian Peninsula. A main part of this project ("Ground Truth Event and Waveform Data Collection for Seismic Calibration of the Arabian Peninsula and Surrounding Regions - Project #35) is to collect calibration data for the primary array near Halban, Saudi Arabia. During the week of January 21-27, 2002, Lawrence Livermore National Laboratory (LLNL) and King Saudi University (KSU) seismologists deployed an autonomous broadband seismic station near Halban. This deployment took advantage of the vault built for station HALM by the 1995-1997 University of California, San Diego (UCSD) Saudi Broadband Deployment (Vernon and Berger, 1998; also funded by DOE). Noise characteristics from the UCSD Deployment indicated that the HALM site was very quiet (Mellors, 1997; Al-Amri *et al*., 1999). Table 1 summarizes seismic station deployments near Halban.

Table 1. Summary of Seismic Station Deployments near Halban, central Saudi Arabia.

Station Code	Institution	On Date	Off Date	Latitude	Longitude	Elevation	Sensor
HALM	UCSD	1995/327	1997/060	22.8454	44.3173	930 m	STS-2
HALB	LLNL/KSU	2002/021	present	22.8452	44.3173	930 m	Guralp-3T
PS38	KACST	To be determined	To be determined	23.4349	44.4894	???	array

Instrumentation

The deployment features a Guralp CMG-3T three-component broadband seismometer (passband 0.008-50 Hz or 125-0.02 s). Data are recorded by a Reftek 72A 24-bit digitizer onto a 1-Gigabyte SCSI field disk. The sample rate is 40/second. Timing is determined every hour by global positioning satellite (GPS) at the site. The system is powered by a 12-V (100-Amp) battery that is recharged by a solar panel. The sensor and digitizer are placed in a vault built for the 1995-1997 UCSD-Saudi Broadband Deployment (Vernon and Berger, 1999). Figure 2 shows the site after installation.

IMS Array Site

The IMS primary seismic station (PS38) is being planned near Halban (Table 1, Figure 3). In April 2001 the Preparatory Commission for the CTBTO and King Abdulaziz City of Science and Technology (KACST) performed a site survey at the KACST-proposed site. During the LLNL-KSU deployment, we learned that the KACST-proposed site is approximately 65 km away from our site. The KACST site is much closer to the highway and the town of Halban. There are many Bedouin encampments closer to the highway and security may be an issue. The array site will require a 4-km by 4-km footprint to be enclosed by a fence. The Hadabat Al-Marhi site is more remote and less likely to be disturbed. Once the site of the array is chosen and secured with a fence, we would like to deploy a station at the exact IMS site. We will then be able to compare observations at both the Hadabat Al-Marhi and IMS array sites to estimate the transfer function between the two sites.

Noise Characteristics and Instrument Response

Noise survey of the 1995-7 Saudi Broadband Deployment found the Halban site to have very low seismic background noise (Mellors, 1997; Al-Amri *et al*., 1999). We compared the noise in a 100-s window for our deployment with a similar window for roughly the same time of day and day of year. The results (Figure 4) show that the noise levels are very similar between our Guralp CGM-3T seismometer and the STS-2 of the 1995-7 Deployment. The noise window for our deployment was taken during the first few days after deployment and the instrument could still have been settling. More analysis will be done as additional data become available.

In order to test the instrument calibration, we computed synthetic seismograms for a moderately large earthquake in the Southern Zagros Mountains (February 17, 2002, M_W 5.3, Harvard CMT). A calibrated model for the Arabian Platform from our previous work (Rodgers *et al*., 1998) was used for the synthetics. Results (Figure 5) show that the data agree well with the synthetics both in amplitude and phase. This indicates that the instrument response and timing have no major problems.

CONCLUSIONS AND RECOMMENDATIONS

We are collecting data for empirical calibration of the Arabian Peninsula at a single broadband station near the planned IMS primary array in central Saudi Arabia (PS38). The deployment is expected to record many events in the seismically active regions surrounding the Arabian Peninsula (e.g. Turkish-Iranian Plateau, Zagros Mountains, Gulf of Aden, Red Sea and Dead Sea Transform). Preliminary analysis of the data show that the noise levels are comparable with the 1995-7 Saudi Broadband Deployment station and that instrument responses are properly calibrated. More data and analysis will be shown at the meeting. Data from the deployment will be distributed on CD ROM.

ACKNOWLEDGEMENTS

Pat Lewis provided essential assistance with the instrumentation before and during the deployment. Don Rock prepared the equipment and loan documentation. Rob Mellors and Frank Vernon kindly provided their field notes and maps to help locate the site. Ahmad Rabie Khalil (KSU) helped set-up the KSU computer system and read the field disks. The primary author thanks the staff of the KSU Seismic Studies Center for their kind hospitality during our visit to Saudi Arabia

REFERENCES

Al-Amri, A. M., R. Mellors and F. Vernon (1999). Broadband seismic noise characteristics of the Arabian Shield, *The Arabian Journal for Science and Engineering*, **24**, 2A, 99-113.

Mellors, R. (1997). Preliminary noise survey and data report of Saudi Arabian data, Lawrence Livermore National Laboratory Informal Document, UCRL-ID-128949.

Rodgers, A., W. Walter, R. Mellors, A. M. S. Al-Amri and Y.-S. Zhang (1999). Lithospheric structure of the Arabian Shield and Platform from complete regional waveform modeling and surface wave group velocities, *Geophys. J. Int*., **138**, 871-878.

Vernon, F. and J. Berger (1998). Broadband seismic characterization of the Arabian Shield, Final Scientific Technical Report, Department of Energy Contract No. F 19628-95-K-0015, 36 pp.

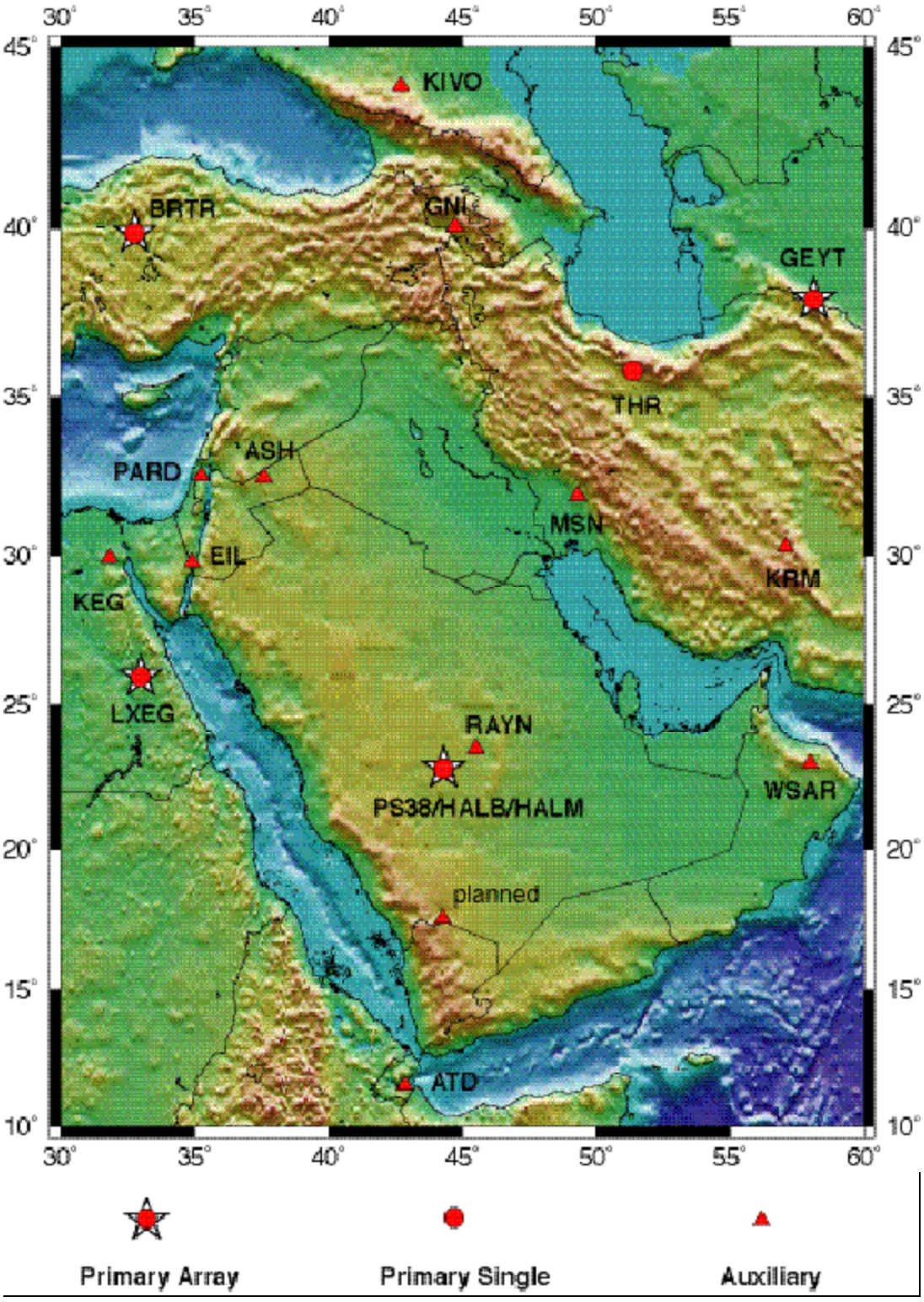

Figure 1. Map of International Monitoring System stations in the Middle East.

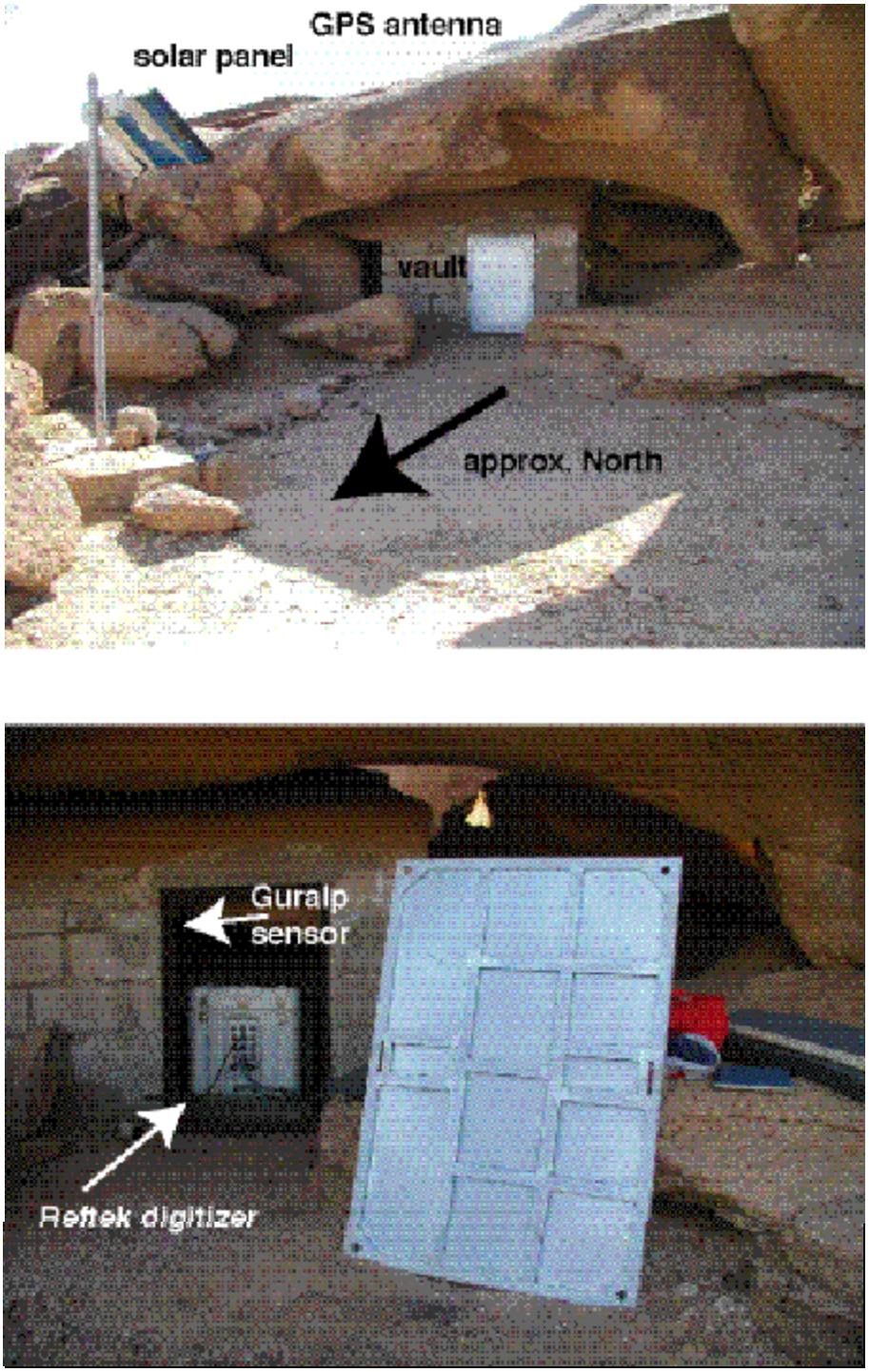

Figure 2. HALB station site. (a) Overview of site showing the vault, solar panel and mast. The GPS antenna is located on the overhanging rock above the vault. The vault door has slots that fit over two protruding U-bolts. Pad locks through the U-bolts secure the door to the frame. (b) Close-up of the vault with the door open. There is a concrete pad inside the vault for the sensor and digitizer.

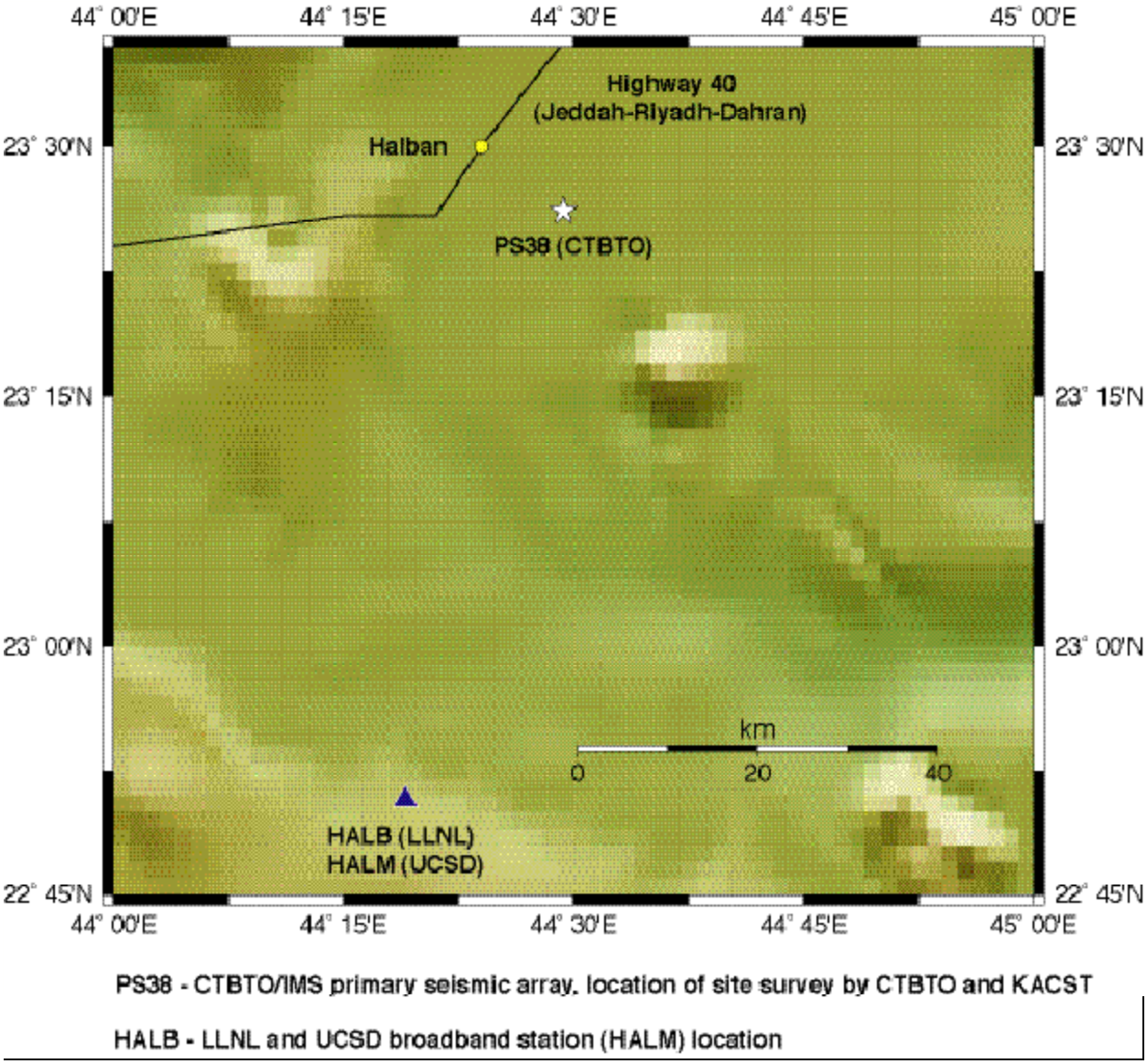

Figure 3. Locations of seismic station deployments, past, present and future, near the town of Halban in central Saudi Arabia.

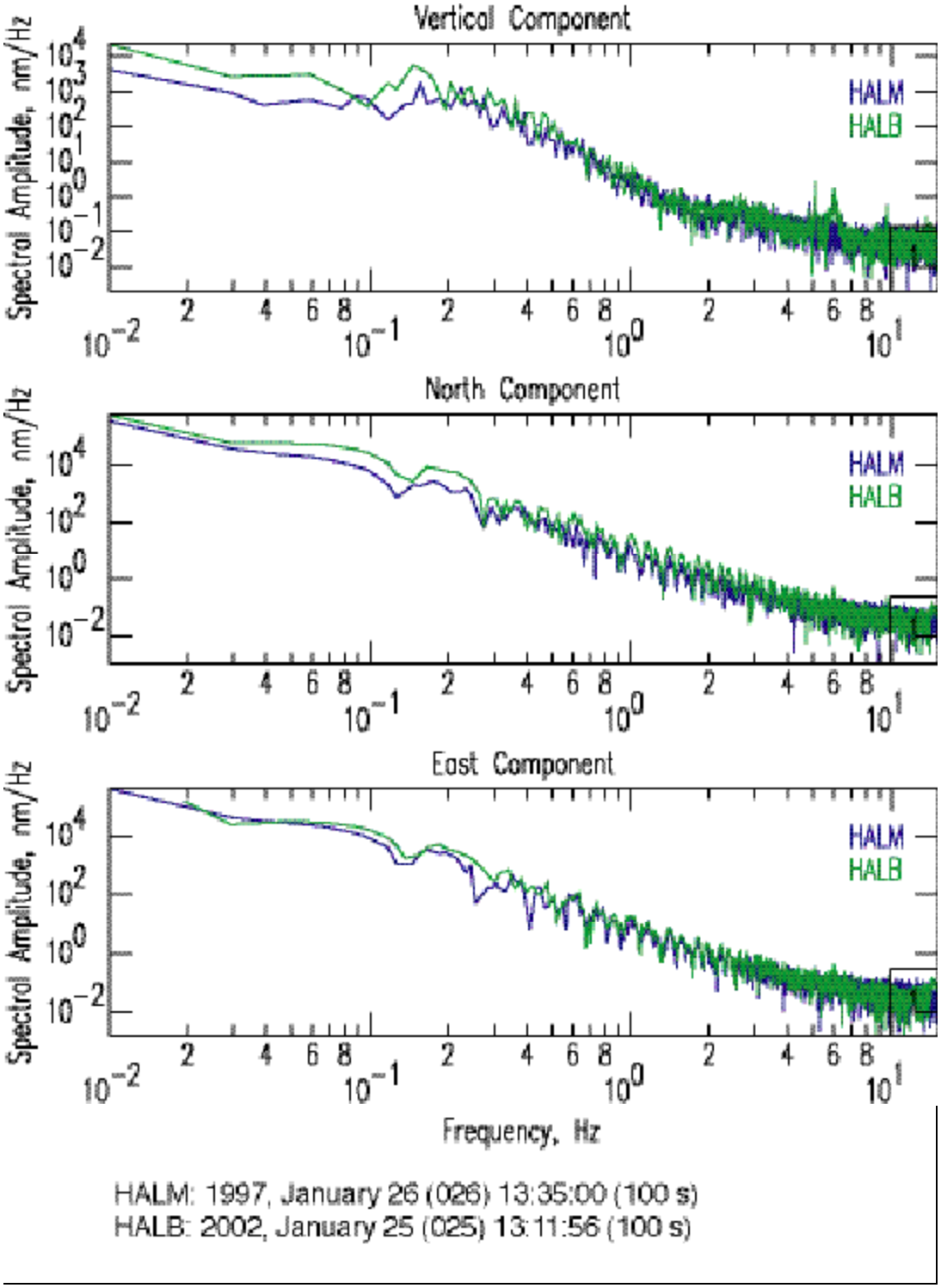

Figure 4. Comparison of noise spectra at HALB (this deployment) and HALM (the 1995-7 Saudi Broadband Deployment, Vernon and Berger, 1998). The comparison was done for a 100-s window at roughly the same time of day and day of year. This plot shows that the noise characteristics of our deployment with a Guralp CGM-3T seismometer are comparable to the STS-2 deployment of Vernon and Berger. More extensive analysis will be performed as more data become available.

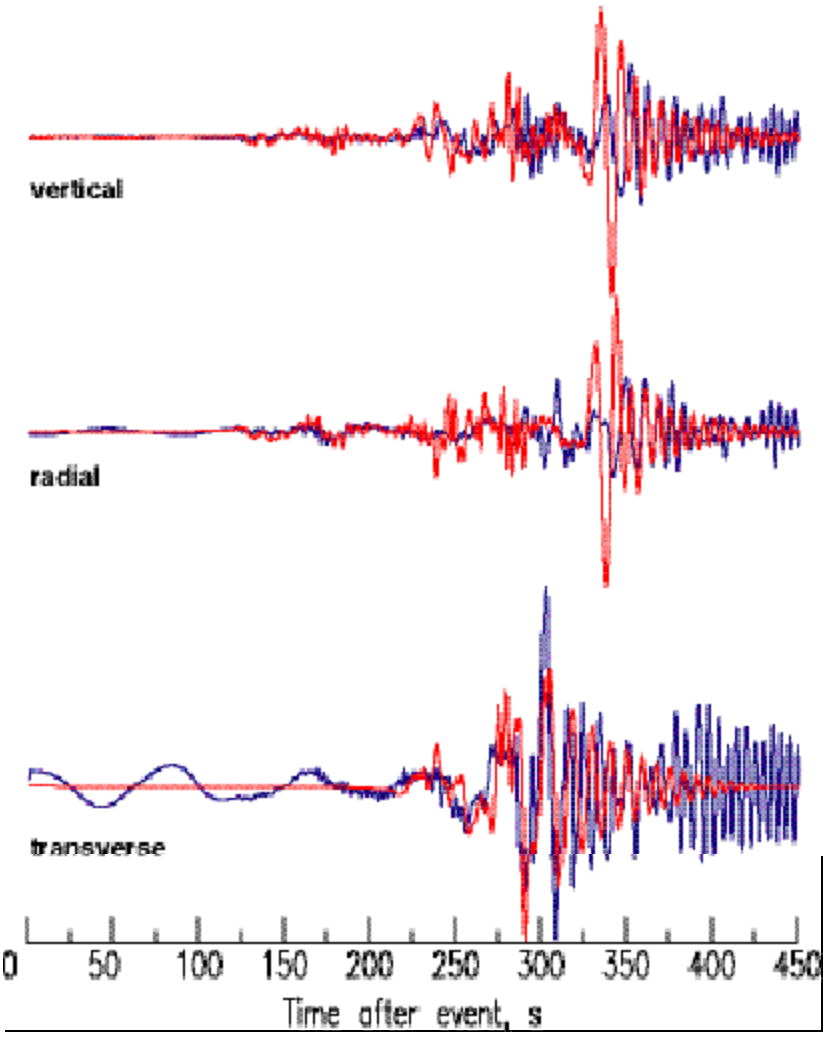

Figure 5. Waveform modeling of the 2002 February 17 (048) Southern Zagros Mountains earthquake. Synthetics were computed from a model derived from similar paths across the Arabian Platform (Rodgers *et al*., 1998). The data (blue) and synthetic (red) were both filtered in the band 80-3 seconds. The focal mechanism and moment were taken from the Harvard CMT Project.