T3.1-P5

A Seismic Noise Survey of Western Kazakhstan

Kevin G. Mackey (mackeyke@msu.edu)[1] Inna Sokolova (sokolova@kndc.kz)[2], Daniel R. Burk (burkdani@msu.edu)[1],
Alik Abishev(abishev.88@mail.ru)[2], Andrey Belyashov (abelyashov@gmail.com)[2], Rongsong Jih (jihrs@state.gov)[3]
1: Department of Earth and Environmental Sciences, Michigan State University 2: Institute of Geophysical Research, Kazakhstan 3: U.S. Department of State, Bureau of Arms Control, Verification, and Compliance

Abstract:

Kazakhstan is strongly committed to and ideally suited geographically for monitoring of nuclear explosions. By contributing key seismic stations and arrays to global and other cooperative efforts, most of the monitoring activities concentrated at sites in Central and Eastern Kazakhstan. Western Kazakhstan contains very few seismic stations and had not been adequately surveyed to identify quiet locations that could improve global monitoring capability. We deployed a temporary network of ten Guralp CMG-3T broadband seismometers in the Mangystau Region of western Kazakhstan, between the Caspian and Aral Seas, in August and September 2016, to identify noise characteristics and quiet sites suitable for monitoring. We found that at frequencies above 1 Hz, noise levels at some stations approach the New Low Noise Model and detection thresholds are similar to permanent borehole stations elsewhere in Kazakhstan. At frequencies below 1 Hz, noise levels are elevated due to microseism generated by the Caspian Sea. The quietist sites were those furthest from the Caspian Sea. On 9 September, 2017, four stations were operating and recorded the DPRK-declared nuclear test with good signal to noise ratios. Overall, stations were quieter and locations better than anticipated, and we feel that efforts to install permanent stations are warranted.

Introduction:

Kazakhstan, centrally located between the Middle East and Asia, is ideally suited to monitor for nuclear explosions in regions of interest. Kazakhstan itself is strongly committed to nuclear explosion monitoring and participates in several global efforts to that end. This project conducted the first systematic noise survey of Western Kazakhstan to determine the region's suitability for permanent monitoring **(Figure 1).**

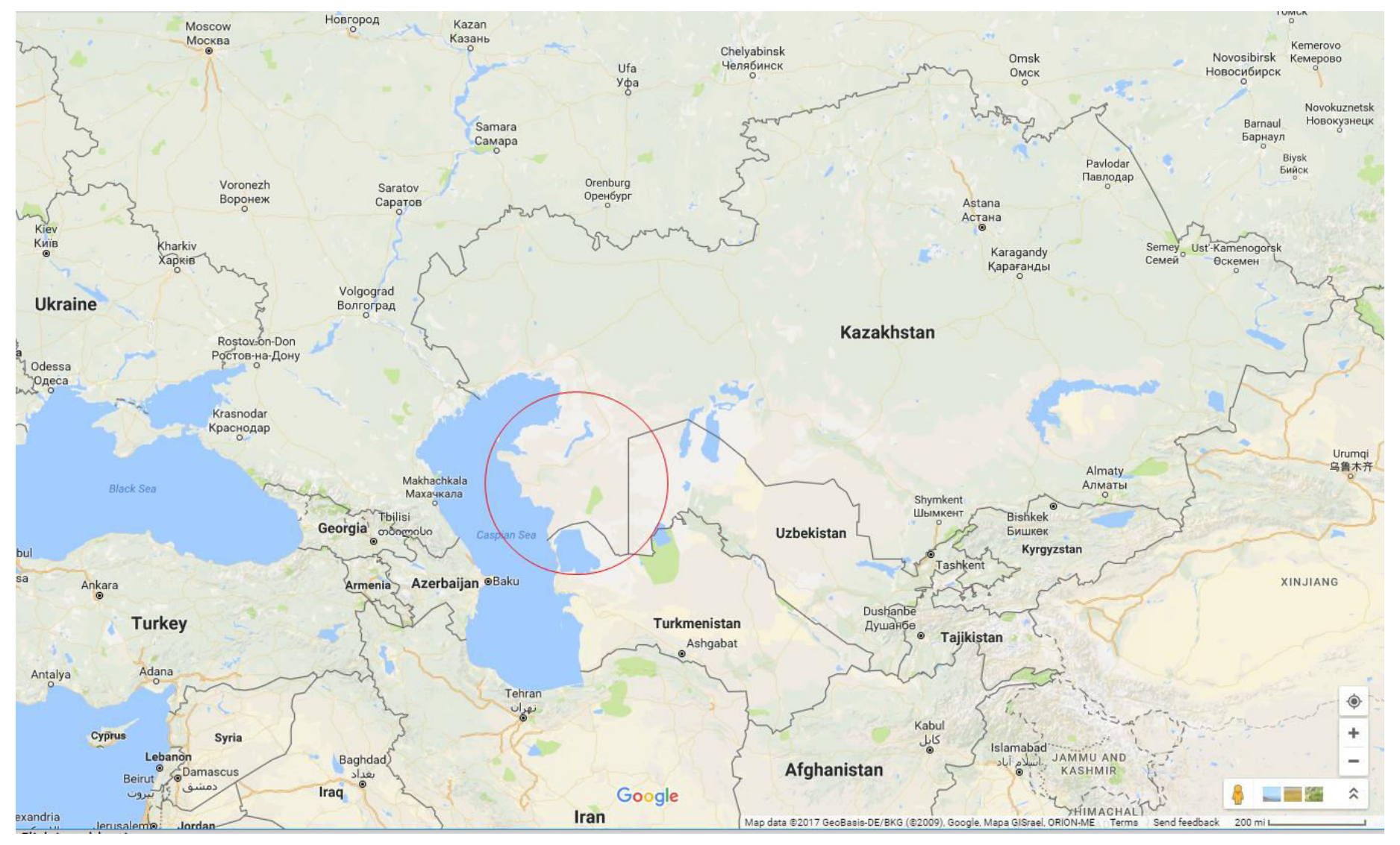


FIGURE 1: Regional map of Central Asia: The study area (red circle) lies between the borders of Uzbekistan, Turkmenistan, and the Caspian Sea.

Why This is Important:

Seismology provides the first physical signal of an underground nuclear test. For successful monitoring, background seismic noise levels must be as low as possible so that events of interest are better detected. Identifying quiet locations for future seismic stations is essential to improve monitoring, particularly at the local and regional scale **(Figure 2).**

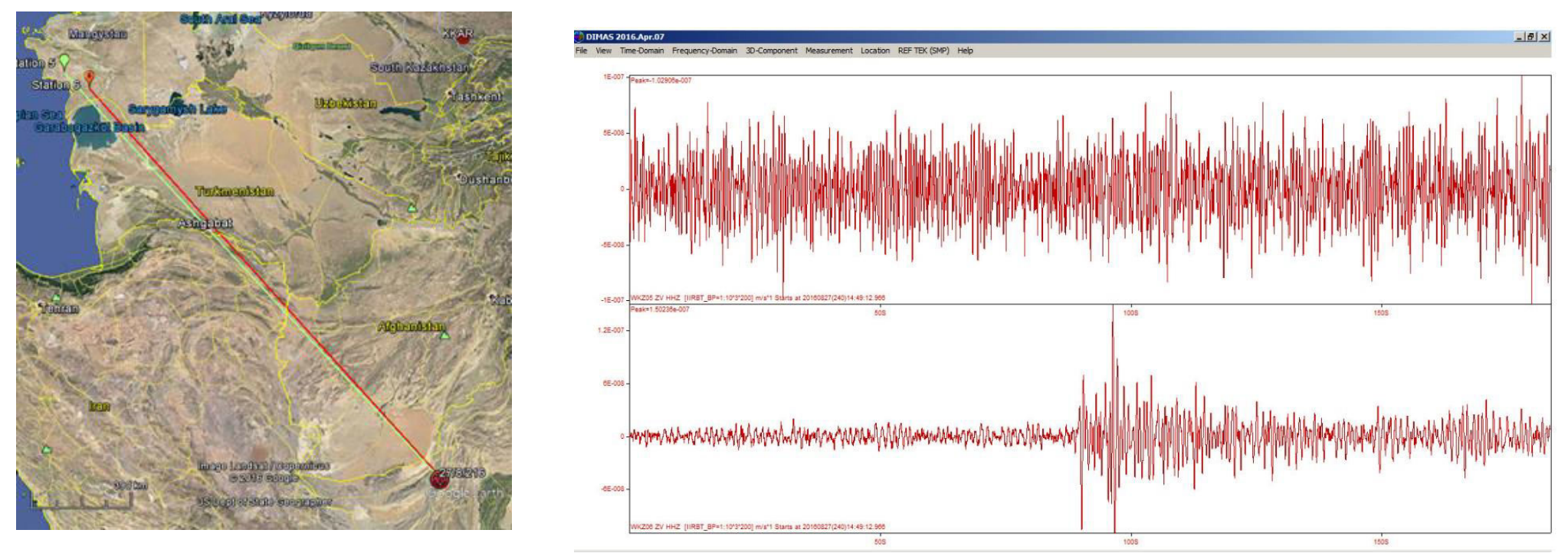


FIGURE 2: Regional event detection:
mb 4.2 W. of Kalat Pakistan on 8/27/2016 recorded at stations WKZ05 (top, 2002 km distant) and WKZ06 (bottom, 1891 km distant). Approximately 200 sec. of record shown. Both records are Z component and band pass filtered 1-10 Hz. WKZ05 is noisy due to nearby active oilfields while WKZ06 is quiet.

Current Monitoring in Kazakhstan:

Monitoring efforts are concentrated at sites in Central and Eastern Kazakhstan. Seismic stations/arrays include Aktyubinsk (AKTO), Kurchatov (KURK), Borovoe (BVRK), Makanchi (MKAR), Karatau (KKAR) and Akbulak (ABKAR; **Figure 3**). Far Western Kazakhstan contains few seismic stations and has not been adequately surveyed to identify seismically quiet locations.

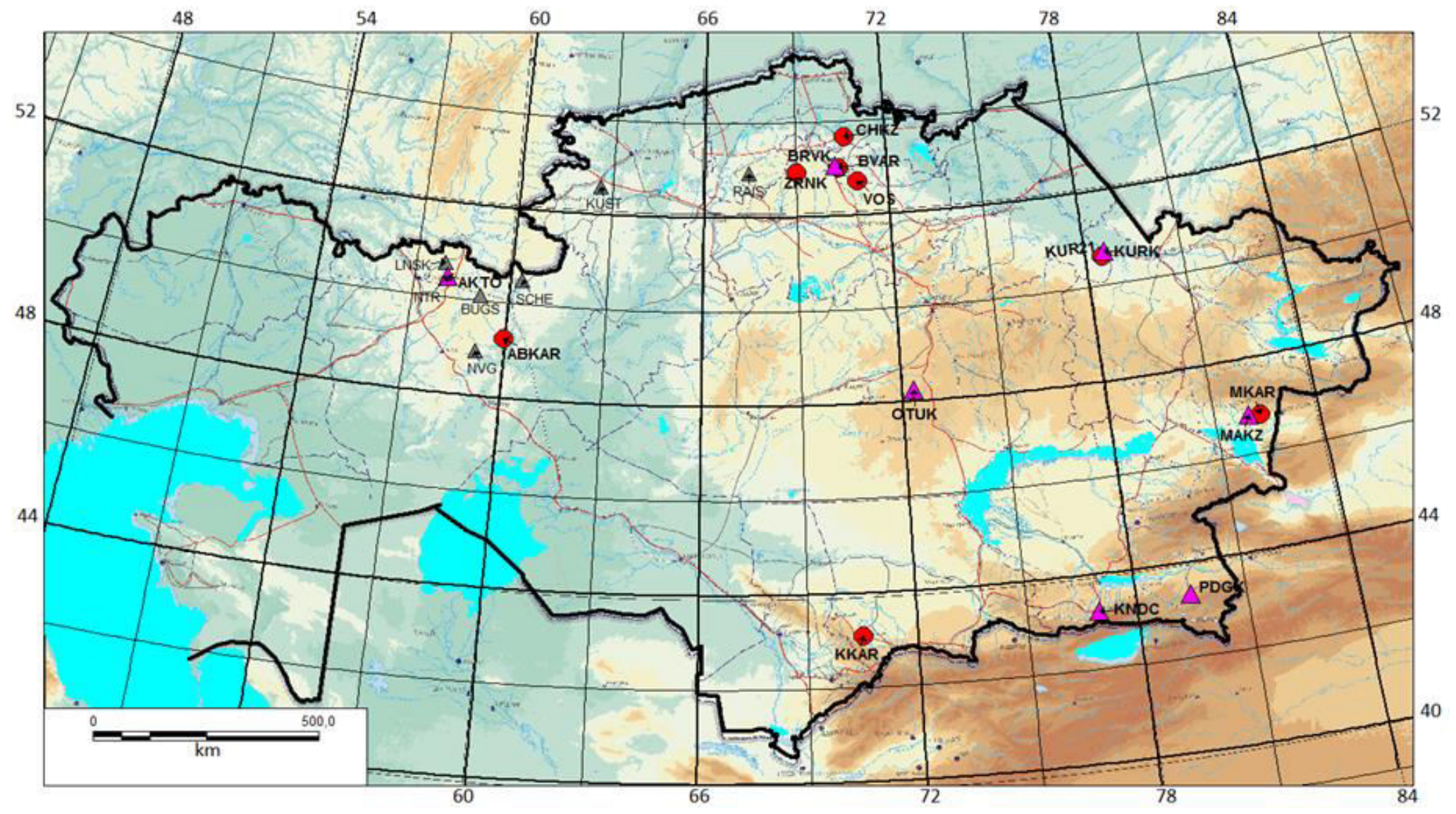


FIGURE 3: Monitoring sites in Kazakhstan

Station Deployments:

10 broadband seismic stations were deployed in different geologic environments in western Kazakhstan **(Figure 4)**. Stations operated between 21 Aug and 12 September, 2016. Each station utilized a Guralp CMG-3T seismometer, Reftek RT-130 datalogger, GPS timing, and batteries with solar panels for power. Stations were installed directly on bedrock, on subsurface bedrock and buried, or directly buried in sediment **(Figures 4 and 5).**

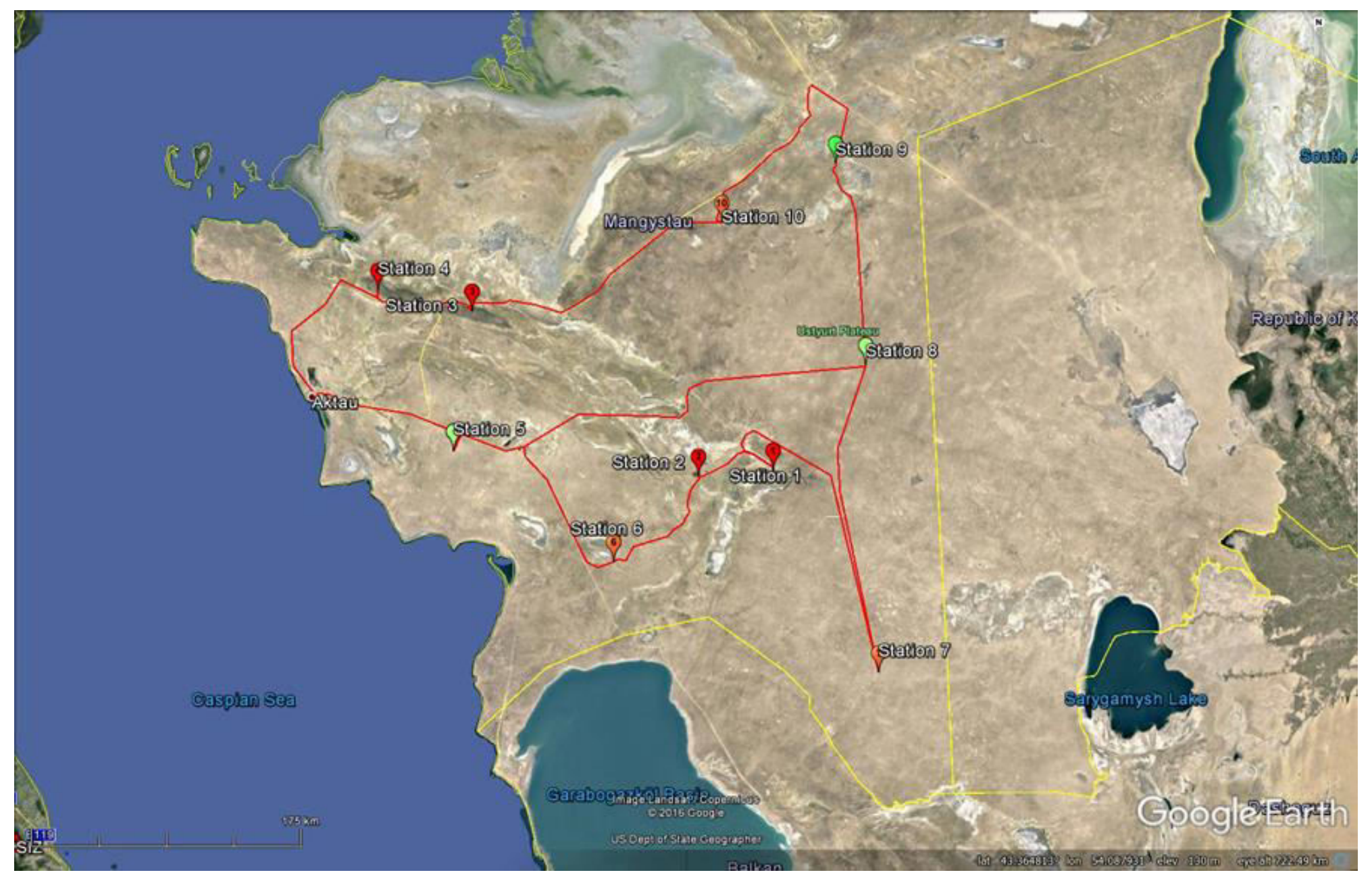


FIGURE 4: Location of ten stations deployed in this study. - Red markers Bedrock installation on Triassic metamorphosed siltstone - Orange markers Bedrock installation on limestone - Green markers Sedimentary installation in loess/clay. Red lines show access routes.

FIGURE 5: Equipment (left) and installation at WKZ02 (right).

Procedures:

For each station, we calculated an average spectral density of daytime and nighttime noise. For each calculation, approximately 10 data segments of 10 minutes each were found that were free of seismic events. For each set of spectrums, the median set was chosen as the most representative and is reflected in all following plots. Instrument responses were taken into account. Results were compared to the New High Noise Model (NHNM) and the New Low Noise Model (NLNM).

Results:

The lowest noise stations from this survey compared favorable to the permanent array stations, especially in terms of short-period noise (0.1 – 0.4 seconds), where the temporary stations are quieter. At the mid-range of 0.4 – 8 seconds, the permanent bore hole outperforms the surface mounted temporary station. At long periods exceeding 8 seconds, the noise levels are similar (**Figure 6**). Note that the temporary surface stations are being compared to permanent bore hole installations. It is likely a bore hole installation at the temporary site would be even quieter.

Geographically, the southeastern stations in unpopulated regions performed the best (such as Station 2, **Figure 7**) . Stations closer to the Caspian Sea have higher noise attributable to oil production, anthropogenic sources, and the Caspian Sea. There was no distinct correlation between noise level and type of installation.

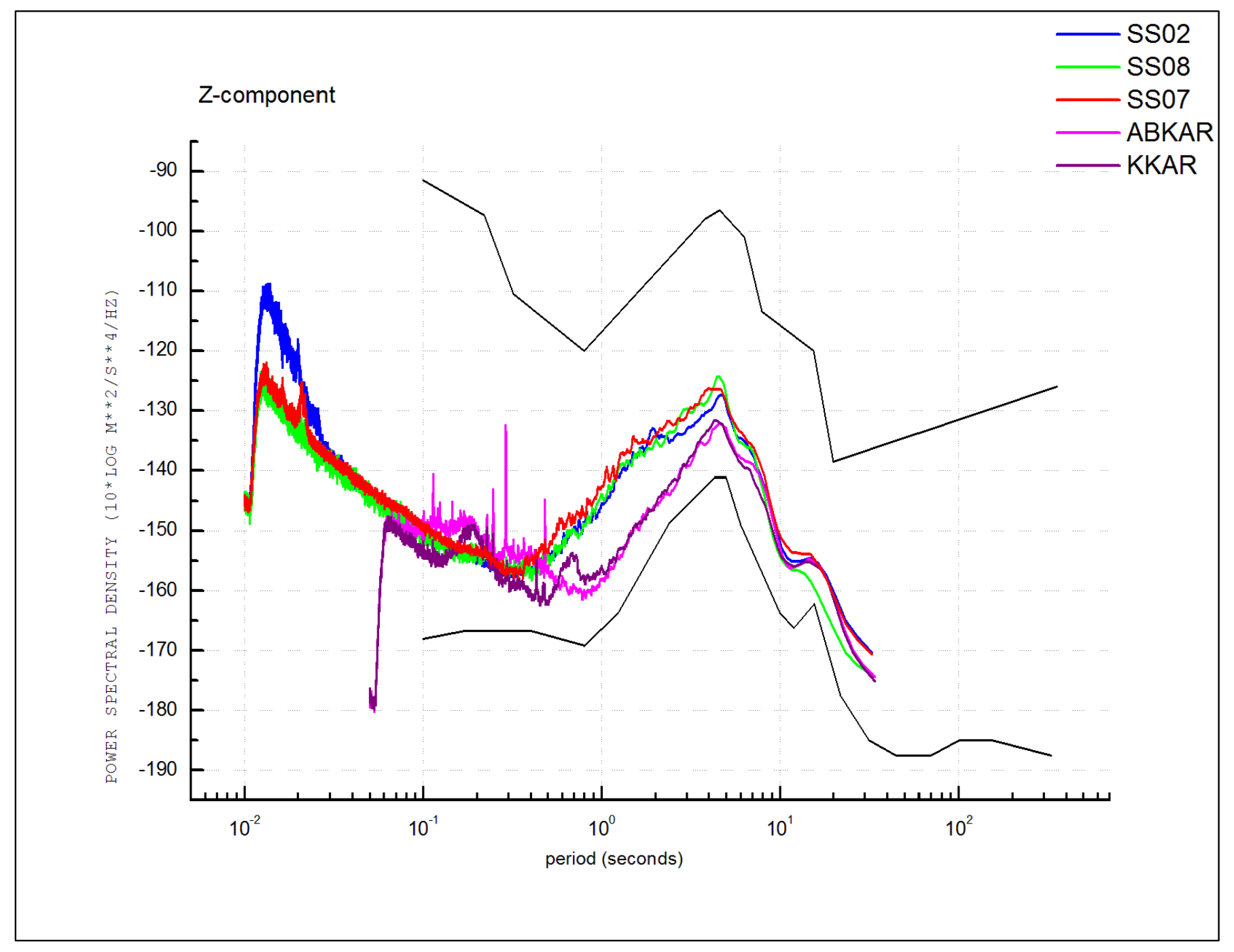


Figure 6: Noise comparison of the quietest temporary (WKZ02, -08, -07) stations to permanent borehole stations (ABKAR and KKAR).

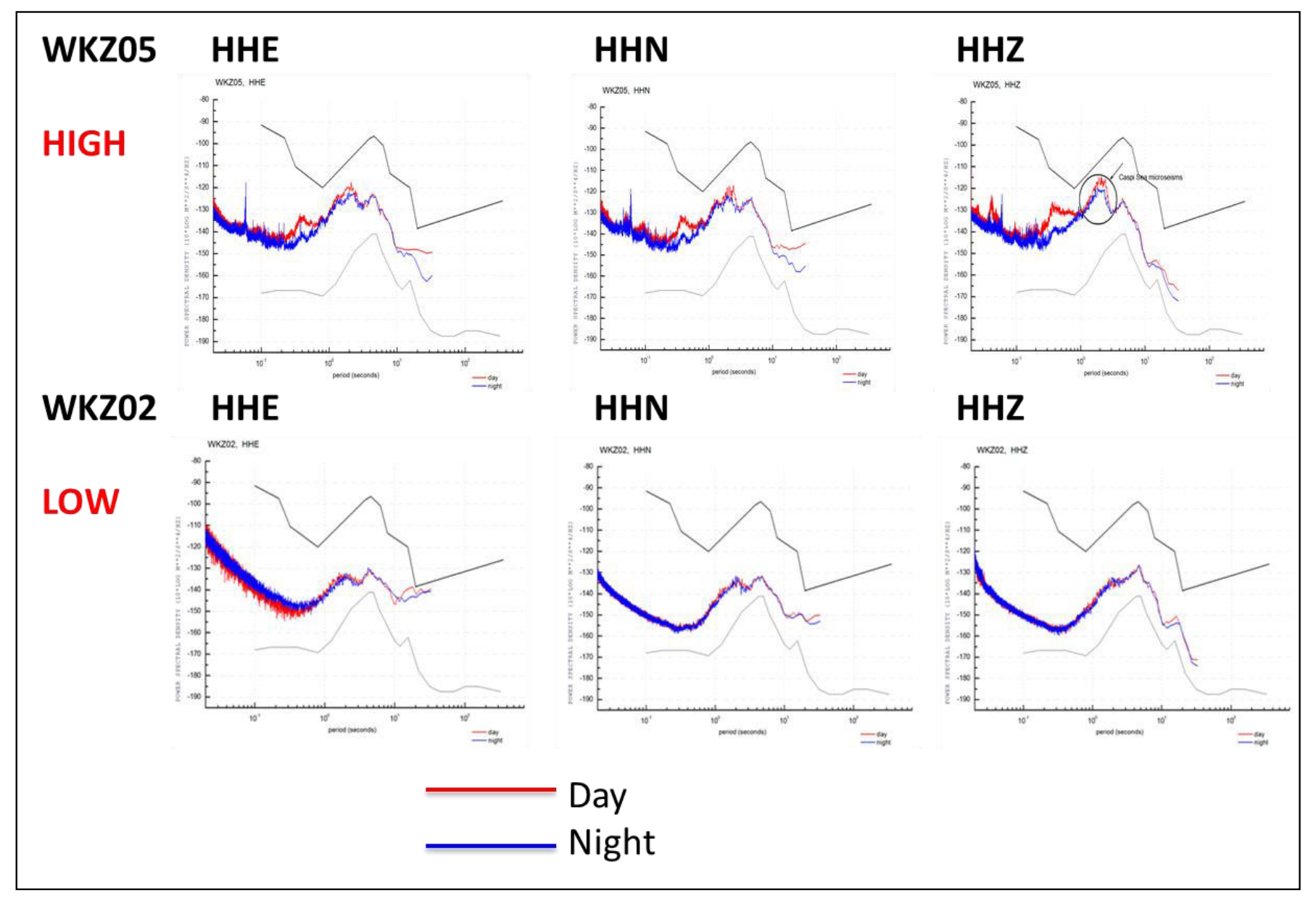
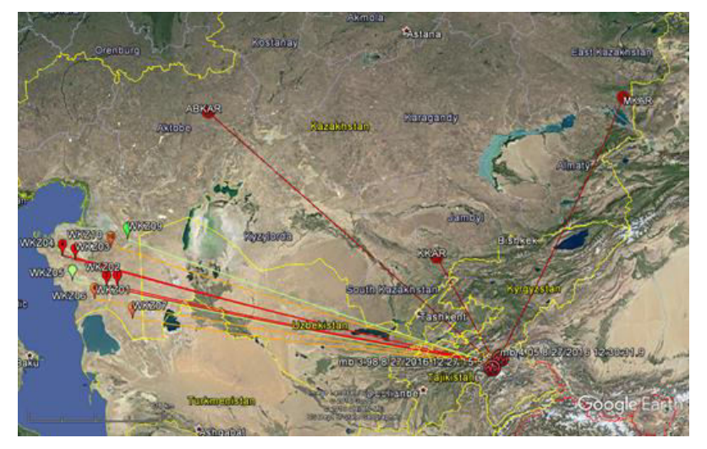


Figure 7: Best and worst noise profiles of the W. Kazakhstan station noise survey

Waveform Comparisons:

Tajikistan Earthquakes



Vertical component waveforms (bandpass filtered 1.5-12 Hz) comparing stations from two events in Tajikistan. The events, easily seen on KKAR, are ~3 minutes apart and have magnitudes of 3.98 and 4.05 respectively. Most W. Kazakhstan stations are as good as ABKAR, and all are better than MKAR, which is closer to the events **(Figure 8).**

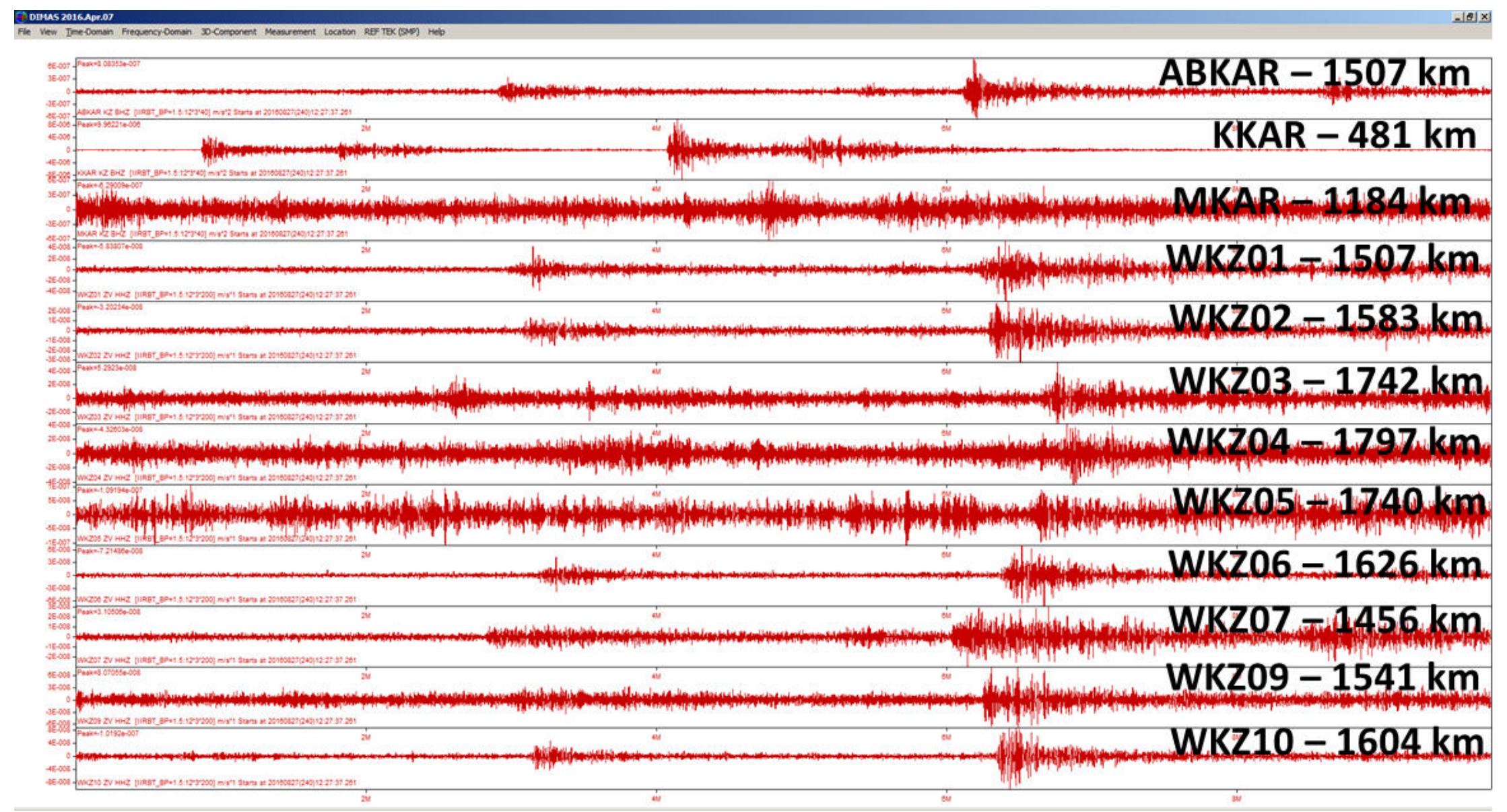


Figure 8: Waveform comparisons from Tajikistan earthquakes.

Iran Earthquake

Vertical component waveforms (bandpass filtered 2-12 Hz) comparing ABKAR (top) and KKAR (second) with Western Kazakhstan stations. The event is a m_b 3.9 earthquake in central Iran. Other W. Kazakhstan stations recorded the event (not shown). Stations WKZ02, -06 and -07 are best **(Figure 9).**

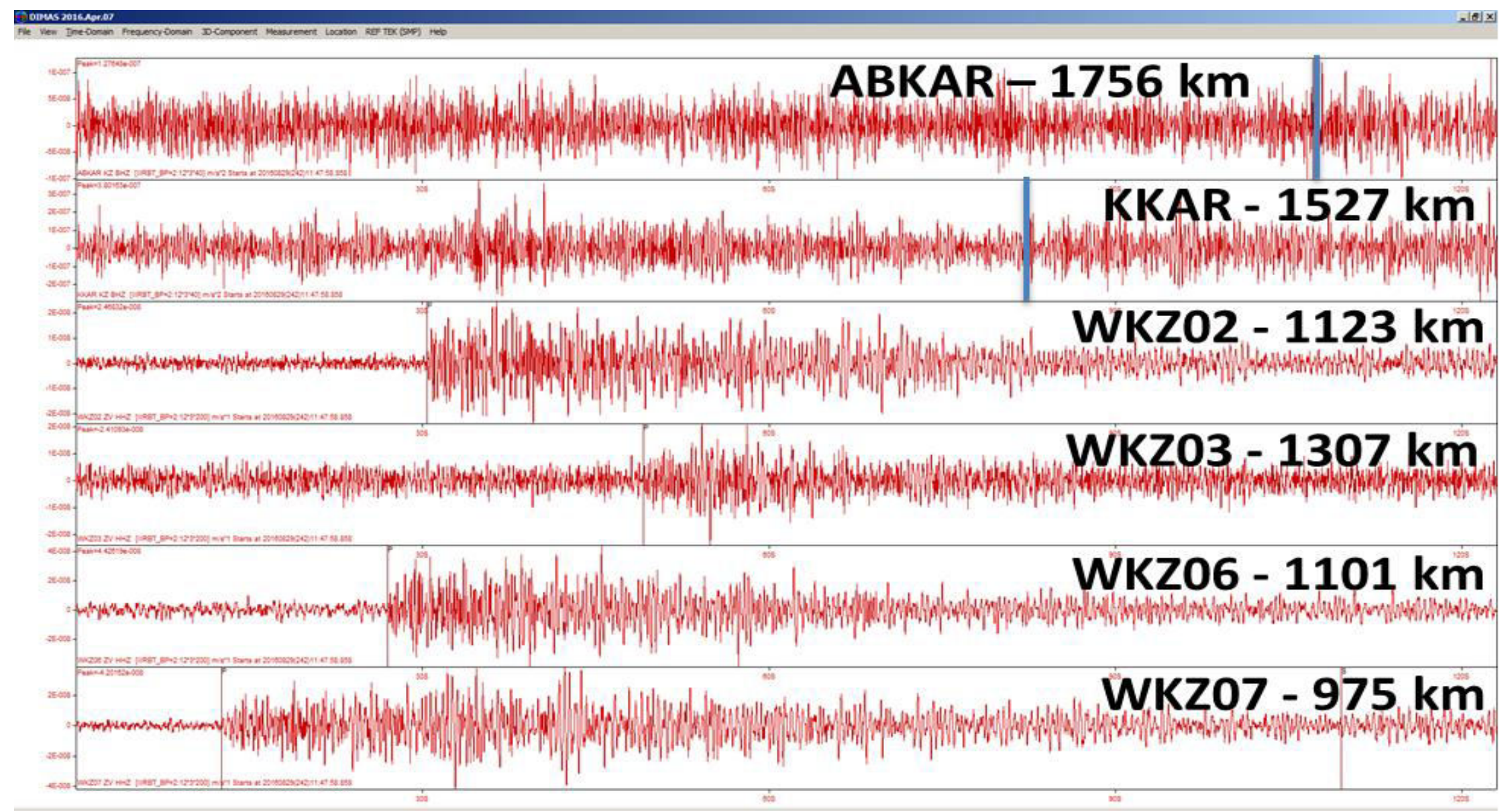


Figure 9: Waveform comparisons from an Iran earthquake. Blue lines indicate theoretical Pn arrivals at ABKAR and KKAR.

09 SEP 2016 DRPK Nuclear Test:

On 9/9/2016, the Democratic People's Republic of Korea detonated their 5th nuclear test. Four stations of the Western Kazakhstan were still deployed and registered the event. Waveforms allow comparison of the W. Kazakhstan stations and regional permanent installations. Recordings at the temporary stations are excellent compared to closer permanent borehole installations **(Figures 10 and 11)**. Unfortunately, the lowest noise W. Kazakhstan stations were removed prior to the test.

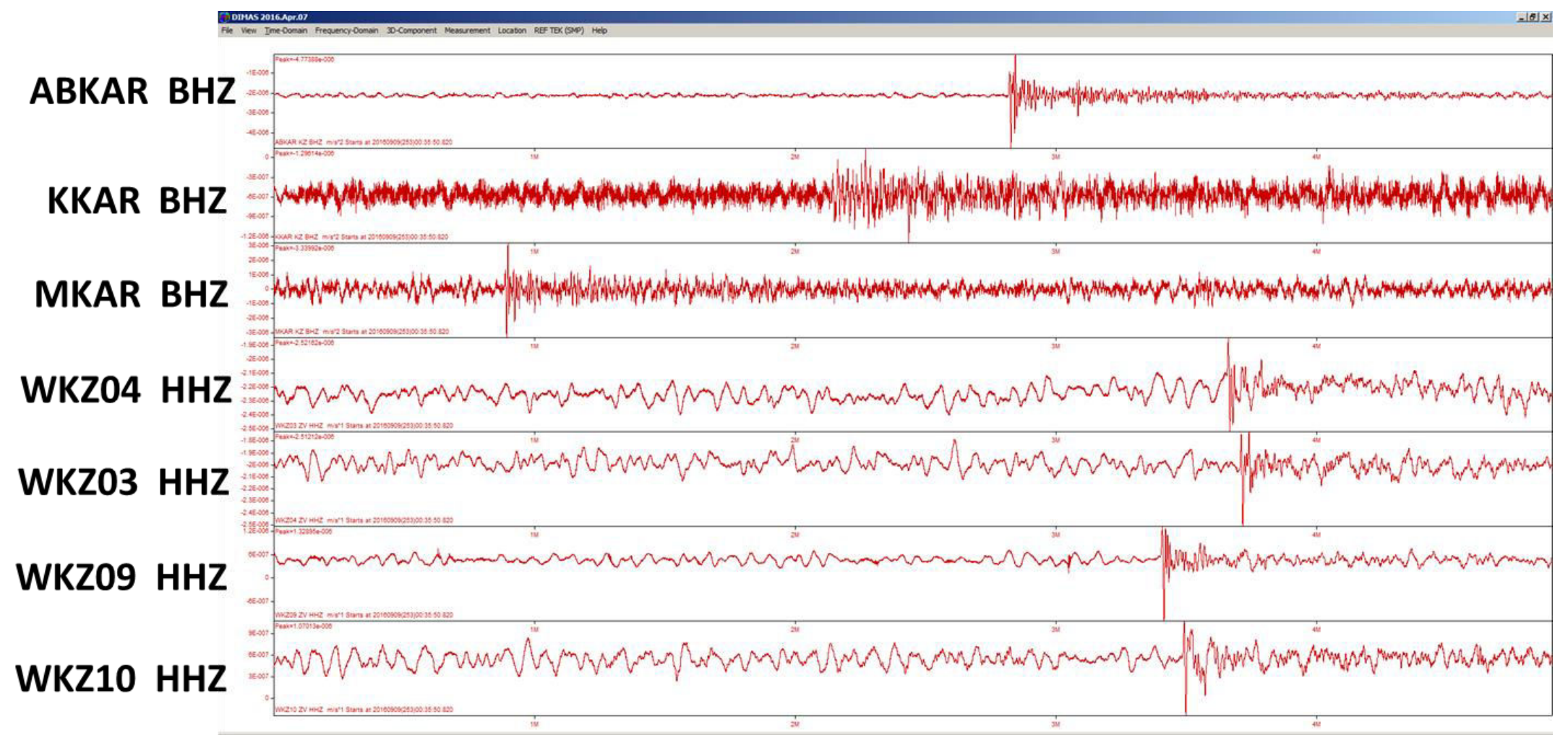


Figure 10: Unfiltered Data comparison of the 09 Sept. 2016 DPRK nuclear test of permanent stations ABKAR, KKAR, MKAR to stations of our W. Kazakhstan temporary deployment.

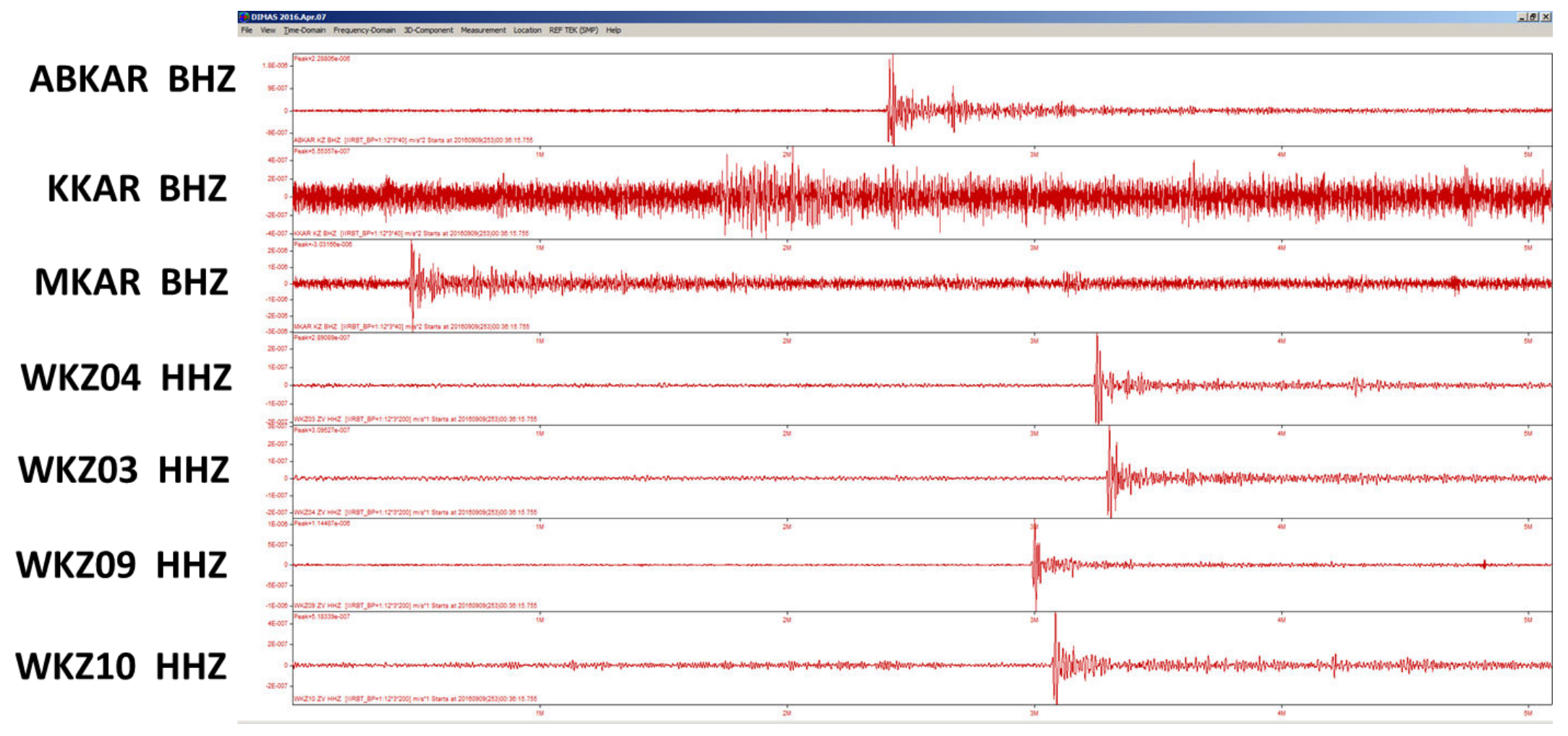


Figure 11: Bandpass (1-12 Hz) filtered data comparison of the 09 Sept. 2016 DPRK nuclear test of permanent stations ABKAR, KKAR, MKAR to stations of our W. Kazakhstan temporary deployment.

Conclusions:

1. Stations WKZ02, -07, -08, in the east and south, and far from the Caspian Sea and cultural objects, are quietest.
2. Station quality is not related to bedrock vs. sedimentary installation.
3. Western Kazakhstan locations have excellent recording at high and low frequencies.
4. Event detection and data quality from Western Kazakhstan temporary surface stations often exceeds that of permanent borehole stations at array sites.
5. Western Kazakhstan temporary stations detect many events that are not recorded by permanent sites.
6. Installation of borehole sensors in the identified quiet regions should further reduce the background noise of stations.

Recommendations:

1. Longer-term studies should be conducted near the identified quiet sites to better understand seasonal noise variation.
2. Future studies should be conducted with an eye towards permanent station deployments.

Acknowledgements:

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