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DISCRIMINATION OF NUCLEAR EXPLOSIONS AND EARTHQUAKES AT REGIONAL DISTANCES FOR THE LOP NOR TEST SITE ACCORDING TO THE KNET NETWORK DATA

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T2.5-P6

In September 1991, a network of digital broadband seismic stations KNET was installed on the territory of Kyrgyzstan. It was first digital seismic network in Central Asia. Currently KNET consists of 10 stations: Ala-Archa (AAK), Alma-Ashu (AML), Chumysh (CHM), Erkin-Say2 (EKS2), Karagay-Bulak (KBK), Kyzart (KZA), Tokmak2 (TKM2), Uchtor (UCH), Ulahol (ULHL) and Uspenovka (USP).

The Kyrgyz National Data Center (NDC-KG) of the Institute of Seismology of National Academy of Sciences of Kyrgyz Republic (IS NAS KR) conducts twenty-four-hour monitoring of seismic events of different nature, in purpose of seismic bulletins and catalogue compilation. For ensuring of good quality of these one it is necessary to know the nature of the event, so far as on the territory of Central Asia except tectonic earthquakes we record a big number of industrial explosions, conducted here. Moreover, Kyrgyzstan is located on regional distances practically from all Asia nuclear test sites (Lop Nor, Pokharan, Chagay) and the task of earthquake and explosion discrimination is very important. Since the beginning of its operation, KNET has registered 8 UNEs from the area of the Chinese test site Lop Nor, 1 from the area of the Indian Pokharan test site, and 2 from the area of the Chagay test site (Pakistan). The main stages of task of seismic discrimination at regional distances consist of: determination of the event location and depth; definition of focal plane solution; the signal spectrum calculation; determination of the ratio of regional phases amplitudes, and the ratio of the magnitudes of surface and body waves. The simplest and most effective method for discrimination of underground nuclear explosions at regional distances is the use of spectral amplitude ratios of regional phases S/P, so far as with nuclear explosions a smaller fraction of energy is emitted in the surface waves than during earthquakes.

The records obtained at digital seismic stations KNET: AAK, AML, CHM, EKS2, KBK, KZA, TKM2 (TKM), UCH, ULHL, USP for 1992-2018 were analyzed. Tectonic earthquakes were selected from the region bounded by the coordinates 40.5°-43.5° N, 86.5°-90.5° E, a total of 22 earthquakes with magnitudes mb = 4.0 ÷ 5.9 were processed (Figure 1). The range of epicentral distances is from 877 km to 1406 km. Figure 2 shows the histogram of epicentral distances distribution for tectonic earthquakes from the area of the Lop Nor test site.

The records of 8 underground nuclear explosions for 1992-1996 with magnitudes mb = 4.9 ÷ 6.5 were processed (Figure 1). The range of epicentral distances is from 1003 km to 1246 km. Figure 3 demonstrates a histogram of epicentral distances distribution for UNEs, conducted at the Lop Nor test site and recorded by the KNET stations. It should be noted that KNET stations locate in a narrow azimuth range Az = 87.7 ÷ 94.7.

Figure 4 shows examples of the UNE seismograms of 1996-06-08, 02: 55: 57.98, φ = 41.657 ° N, λ= 88.690 ° E, mb = 5.9 [2], and the tectonic earthquake of 1991-01-30, 03: 51: 05.42, φ = 41.674 ° N, λ= 88.463 ° E, Mw = 5.5 from the test site area.

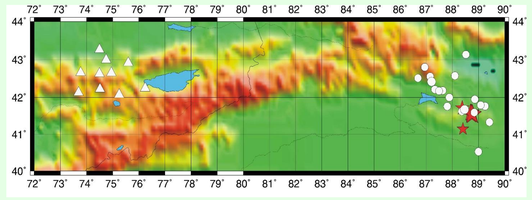


Figure 1. Map of KNET stations location (triangles), UNEs (stars), earthquakes (circles).

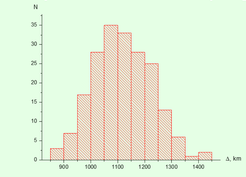


Figure 2. Histogram of epicentral distances distribution for tectonic earthquakes from the region and near the Lop Nor test site.

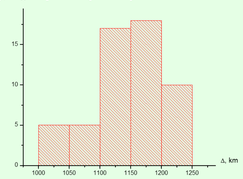
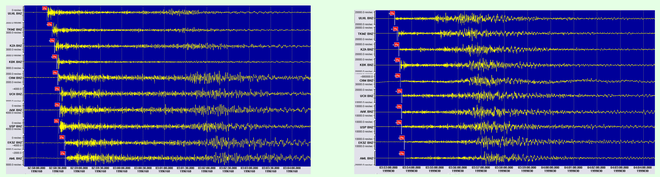


Figure 3. Histogram of epicentral distances distribution for UNEs, conducted at the Lop Nor test site and recorded by the KNET stations.



a) b)

Figure 4. Seismograms: a) UNE of 1996-06-08, 02:55:57.98, φ=41.657°N, λ= 88.690°E, mb= 5.9; b) tectonic earthquake of 1999-01-30, 03:51:05.42, φ=41.674°N, λ=88.463°E, Mw=5.5 in the area of test site.

Seismic records were pre-filtered. Filters with central frequencies of 0.6, 1.25, 2.5, 5 Hz and a bandwidth of 2/3 octaves at –3 dB level from the maximum were used (Figure 5). The total frequency range was determined by the equipment characteristics, magnitude and epicentral distances, and the signal-to-noise ratio did not allow conduct measurements outside of this range.

Maximum amplitudes of Pn, Pg, Sn, Lg phases were measured, and decimal logarithms of amplitude ratios lg (ASn/APn) (in short - Sn/Pn), lg(ALg/APg) (in short - Lg/Pg) were analyzed.

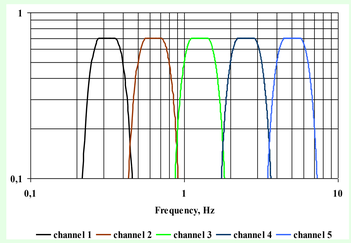


Figure 5. Frequency responses of narrowband channels of frequency selective seismic station.

For the AAK station, records of 6 UNEs (Δ = 1146 ÷ 1182 km) and 19 tectonic earthquakes (Δ = 1034 ÷ 1347 km) were processed. Figure 6 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed for both Sn/Pn and Lg/Pg ratios.

For the AML station, records of 4 UNEs (Δ = 1243 ÷ 1246 km), and 18 tectonic earthquakes (Δ = 1066 ÷ 1409 km) were processed. Figure 7 presents the distributions of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed only for the Lg/Pg parameter.

For the CHM station, records of 6 UNEs (Δ = 1126 ÷ 1162 km), and 20 tectonic earthquakes (Δ = 991 ÷ 1331 km) were processed. Figure 8 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies 2.5, 5.0 Hz is observed only for the Lg/Pg parameter.

For the EKS2 station, records of 6 UNEs (Δ = 1205 ÷ 1241 km), and 21 tectonic earthquakes (Δ = 1054 ÷ 1406 km) were processed. Figure 9 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed for both Sn/Pn and Lg/Pg values.

On the KBK station, records of 6 UNEs (Δ = 1109 ÷ 1145 km) and 21 tectonic earthquakes (Δ = 959 ÷ 1311 km) were processed. Figure 10 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed for both Sn/Pn and Lg/Pg parameters.

On the KZA station, records of 4 UNEs (Δ = 1085 ÷ 1119 km) and 17 earthquakes (Δ = 940 ÷ 1281 km) were processed. Figure 11 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies 2.5, 5.0 Hz is observed only for the Lg/Pg parameter.

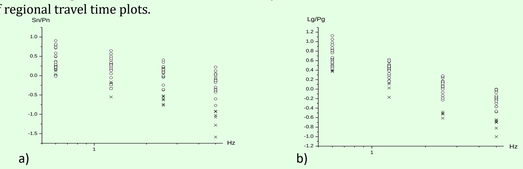
On the TKM2 (TKM) station, records of 5 UNEs (Δ = 1057 ÷ 1116 km), and 20 tectonic earthquakes (Δ = 923 ÷ 1262 km) were processed. Figure 12 presents the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed for both Sn/Pn and Lg/Pg parameters.

On the UCH station, the records of 3 UNEs (Δ = 1145 ÷ 1179 km), and 17 tectonic earthquakes (Δ = 998 ÷ 1342 km) were processed. Figure 13 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed for both Sn/Pn and Lg/Pg values.

On ULHL station, records of 4 UNEs (Δ = 1003 ÷ 1036 km), and 20 tectonic earthquakes (Δ = 877 ÷ 1201 km) were processed. Figure 14 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed for both Sn/Pn and Lg/Pg parameters.

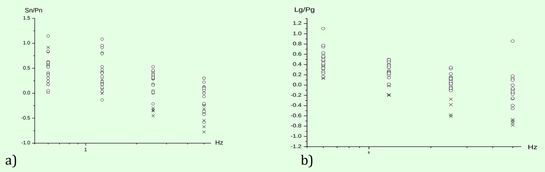
On the USP station, records of 5 UNEs (Δ = 1148 ÷ 1185 km), and 19 tectonic earthquakes (Δ = 994 ÷ 1355 km) were processed. Figure 15 shows the distribution of Sn/Pn and Lg/Pg values for explosions and earthquakes from the area of the Lop Nor test site. A good discrimination of parameters at frequencies of 2.5, 5.0 Hz is observed for Lg/Pg parameter and at a frequency of 5 Hz - for the Sn/Pn parameter.

As a result of this investigation, it was found out that the KNET stations can be successfully used for discrimination of the nuclear explosions and earthquakes for the area of the Lop Nor test site. The best discrimination parameter is the spectral Lg/Pg ratio for filters with central frequencies of 2.5 and 5 Hz. Sn/Pn parameter is effective for AAK, EKS2, KBK, TKM2, UCH stations. Created database of the nuclear explosions records can be successfully used for the calibration of seismic stations in Kyrgyzstan, as well as for creation of regional travel time plots.



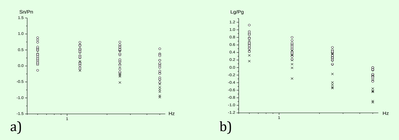
a) b)

Figure 6. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. AAK station.



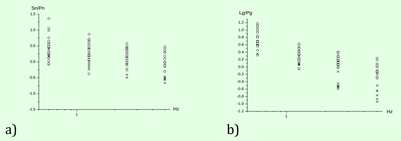
a) b)

Figure 7. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. AML station.



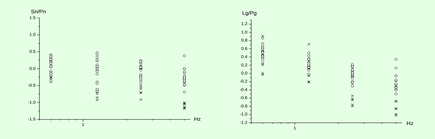
a) b)

Figure 8. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. CHM station.



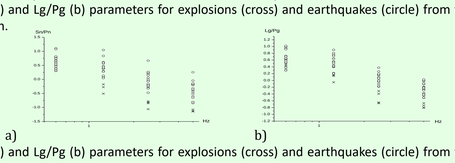
a) b)

Figure 9. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. EKS2 station.



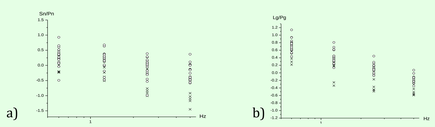
a) b)

Figure 10. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. KBK station.



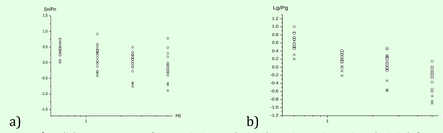
a) b)

Figure 11. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. KZA station.



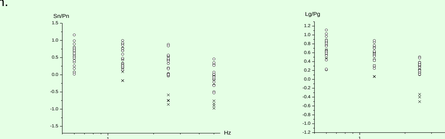
a) b)

Figure 12. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. TKM2 station.



a) b)

Figure 13. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. UCH station.



a) b)

Figure 14. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. ULHL station.

a) b)

Figure 15. Distribution of Sn/Pn (a) and Lg/Pg (b) parameters for explosions (cross) and earthquakes (circle) from the area of the Lop Nor test site. Z channel. USP station.