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NEW STAGE OF WORKS ON NUCLEAR EXPLOSIONS HISTORICAL RECORDS DIGITIZATION

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During the past twenty years the Institute of Geophysical Research has been conducting a regular work on digitizing and scanning of photo- and paper seismograms stored in archives of different organizations. Under support of the international and foreign organizations in different years there were works with records of nuclear explosions conducted at different Test Sites of the world. This work was conducted under the ISTC, LDEO, NORSAR, AFTAC Projects, and under the award of Kazakhstan government. It was managed to digitize the records of nuclear explosions from different Test Sites of the world: Semipalatinsk Test Site, Novaya Zemlya, peaceful nuclear explosions conducted on the territory of the USSR, Lop Nor, Nevada, Amchitka, Mururoa and Fangataufa, In Ekker, Pokharan, Chagay, and peaceful nuclear explosions conducted on the territory of the USSR. In total, the database contained more than 7000 seismograms, Figure 1.

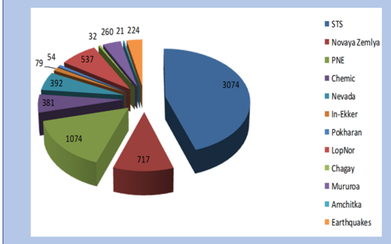


Figure 1. Distribution of digitized records of explosions by the world Test Sites. The share of digitized earthquakes records is also shown.

From June 2018, a new joint project with AFTAC was started. This project is focused on nuclear tests conducted at the Semipalatinsk Test Site. It is very important that the works on digitizing of analogue seismograms implemented under different projects result in records unified by formats, generalized by united metadata formats allowing creating a united database of digitized nuclear tests by Central Asia stations.

To date, about 1200 seismic records of underground nuclear explosions recorded at epicentral distance Δ=160÷4300 km and magnitude range mb=3.22÷6.3 were digitized. Figure 2 shows a map of seismic stations location which records were used for digitization. Figure 3 shows a histogram of epicentral distance distribution, most of UNE were at epicentral distance 500 – 1500 km. Figure 4 shows digitized records of UNE conducted at the STS on October 14, 1965, t0=4-00-00.2, φ=49.9906°, λ=77.6357°, mb=4.28.

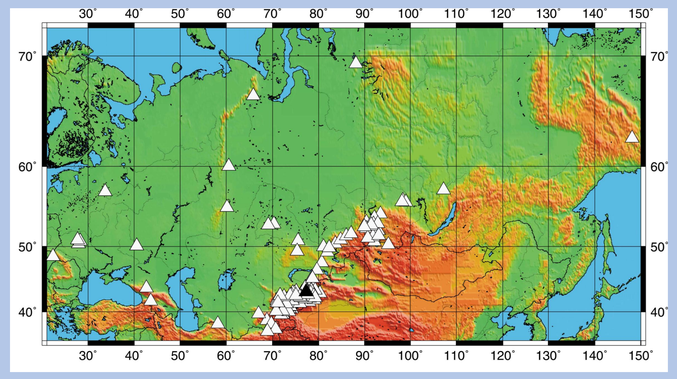


Figure 2. The map of seismic stations location which records were used for the digitization. Black triangle is Talgar observatory.

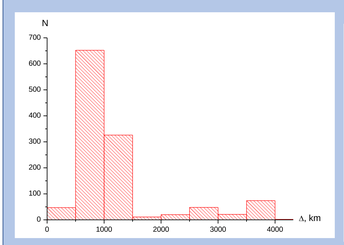


Figure 3. A histogram of digitized records distribution by epicentral distance.

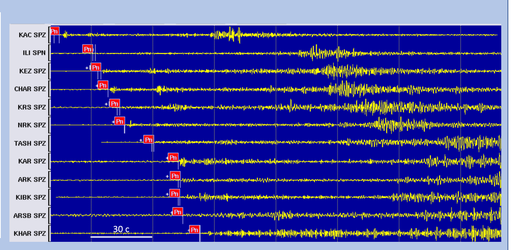


Figure 4. Digitized seismic records of UNE conducted at the STS on October 14, 1965, t0=4-00-00.2, φ=49.9906°, λ=77.6357°, mb=4.28. Z-components.

In comparison to previous works on digitization this Project pays much attention to digitization of the microbarograph records that was installed at Talgar Observatory and recorded infrasound signals from the regions of the STS, Lop Nor, Novaya Zemlya Test Sites. Figure 4 shows the location of Talgar station and places of atmosphere explosions. Despite remoteness of the station from the UNE conducting places, these records are of much interest for researchers as these are the only records of nuclear explosions recorded by the microbarograph and kept in archives of Kazakhstan. The microbarograph had been operating on the territory of the Observatory since 1962; it recorded infrasound signals from large atmosphere nuclear explosions conducted at Semipalatinsk Test Site (1962), at Novaya Zemlya Test Site (1962), Lop Nor (1966 – 1976). The recording by the microbarograph was on photopaper. Figure 6 shows a scheme of the microbarograph operated that time on the territory of Kazakhstan and dependence of its sensitivity on oscillation period (Figure 7) [1].

Below are the examples of infrasound signals records obtained from the regions of the Test Sites.

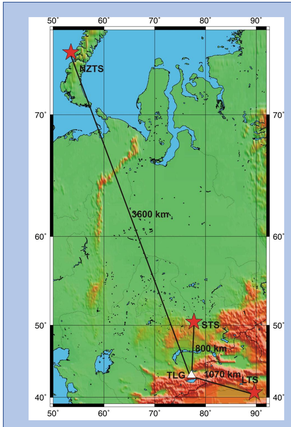


Figure 5. Location of Talgar station and places of atmosphere explosions.

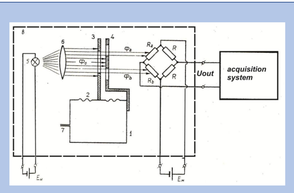


Figure 6. A scheme of microbarograph [1].

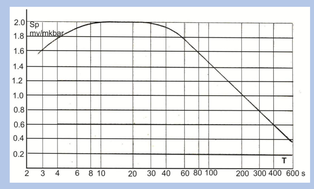


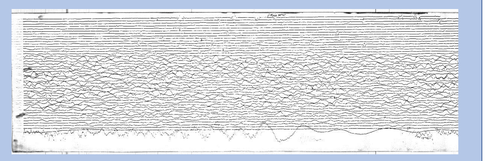
Figure 7. Dependence of the microbarograph sensitivity on oscillation period.

Novaya Zemlya.

The Northern Test Site Novaya Zemlya is located in the Russian Federation (former RSFSR) on the territory of Novaya Zemlya archipelago being a part of Archangelsk region. The archipelago consists of two large islands – northern and southern divided by Matochkin Shar strait. The northern island is ~49000 km2, and southern ~33200 km2 [2]. The archipelago is extended from the north to the south for about 750 km, its width is 140 km. Figure 8 shows the testing zones of the Test Site. From 1955 to 1990 on the territory of Novaya Zemlya Test Site there were 130 nuclear explosions, among them 88 atmosphere, 3 underwater, and 39 underground nuclear tests. Total yield of the explosions was 265 megaton [2-6]. In the zone "A" (the area of Chernaya Bay) there were atmosphere nuclear explosions of one kiloton, underground nuclear explosions in shafts, and a surface nuclear explosion, 3 underwater and 2 above water nuclear tests. In the zone "B" there were underground nuclear explosions in tunnels (mountainous areas Moyiseyeva and Lazareva). In zone "C" there were tests of multi-megaton nuclear charges dropped from planes [2].

In the archive of CSE, 19 records of acoustic signals from explosions conducted at Novaya Zemlya Test site recorded by Talgar station were found. In some cases, the recording of atmosphere nuclear explosion by the seismic station was absent, but there was recoding of acoustic wave by a microbarograph. Figure 9 shows the analog record, digitized record and spectrum of the nuclear explosion conducted on August 27, 1962, t0=09-00-50.9, φ=74.7°, λ=50.3°, altitude 3000 m, yield Y=4200 Kt. The explosion yield for which acoustic signals were found ranges from 8.3 Kt – 25 Mt. The signals are long-period, peak period is 210 s, average travel-time to the station is ~ 3 hours, 11 min, acoustic wave velocity is vi= 313±4 m/s.

Figure 8. Boundaries of the testing subareas of the Novaya Zemlya Test Site (NZTS). A, B, and C denote three main areas (zones) of military activity [2].



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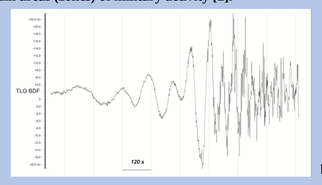

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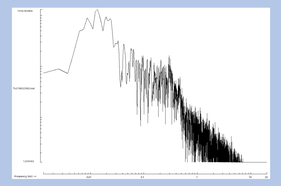


c)

Figure 9. The microbarograph record of the nuclear explosion conducted on August 27, 1962, t0=09-00-50.9, φ=74.7°, λ=50.3°, altitude 3000 m, yield Y=4200 Kt: a – analogue record; b – digitized record; c – spectrum. TLG station.

Lop Nor

Lop Nor Test Site is located at Xinjiang province (north-west China), about 600 km south-eastward from Kazakhstan-Chinese border. In 1964-1996 there were 45 nuclear tests, including 3 surface, 20 atmosphere and 22 underground explosions [6]. The underground nuclear explosions were conducted in boreholes and horizontal tunnels (Figure 10). There is no information on the charge depth. Maximum yield of atmosphere explosions reached Y=4 Mt – for the explosion on November 17, 1976; for underground nuclear tests the maximum yield was Y=660 Kt for the explosion conducted on May 21, 1992 [6].

In the CSE archive 7 records of acoustic signals from explosions conducted at Lop Nor Test Site and recorded by Talgar station were found. The microbarograph records were collected and analyzed; Figure 11 shows the analog record of nuclear explosion conducted on November 17, 1976, t0=06-00-12.7, φ=40.696°, λ=89.627°, the explosion altitude is unknown, yield Y=4000 Kt, digitized record and spectrum.

The range of explosions yield for which the acoustic signals were found is 0.3-4 Mt. The signals were long-period, maximum period was 120 s, average travel-time to the station was ~ 58 min.

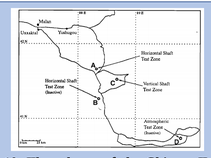
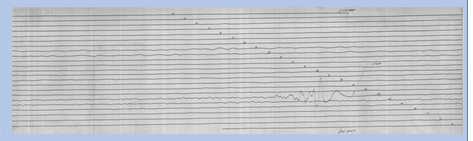


Figure 10. The scheme of the Chinese Test Site. A- testing zone with horizontal tunnels; B – testing zone with horizontal tunnels; C – testing zone with vertical shafts; D – zone for atmosphere tests [7].



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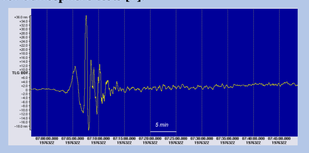

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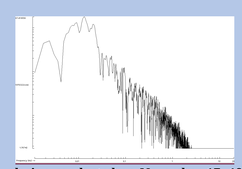


c)

Figure 11. The microbarograph record of atmosphere nuclear explosion conducted on November 17, 1976, t0=06-00-12.7, φ=40.696°, λ=89.627°, for TLG station, Δ=1065 km, a) analogue record, b) digitized record, c) spectrum.

Semipalatinsk Test Site.

Semipalatinsk Test Site is located in Kazakhstan on the territory of three regions (eat Kazakhstan, Pavlodar, and Karaganda); it is 180 km long and 140 km width. The Test Site area is 18450 km2. Geographic coordinates of the territory center are 50° N, 78° E. Regarding the topography the STS territory is presented by different types of relief – flatland within Balapan and Opytnoye Polye sites, and mountainous within Degelen and Murzhyk sites [8] (Figure 12).

456 nuclear tests were conducted at the STS in 1949-1989, among them there were 116 atmosphere and surface, and 340 underground nuclear explosions. The tests were conducted under different technical conditions (in atmosphere, in vertical boreholes, horizontal tunnels etc). The UNE depth for boreholes at Balapan site was from 150 m to 700 m. The yield of nuclear charges varied from 0.001 to 1500 Kt [6, 9]. Surface and atmosphere tests were conducted at Opytnoye Polye in 1949-1962 (Figure 12b).

Figure 13 shows the microbarograph record of nuclear explosion conducted on October 13, 1962, t0=09-00-17.5, φ=50.4227°, λ=77.7231°, altitude 720 m, Y=4.9 Kt.

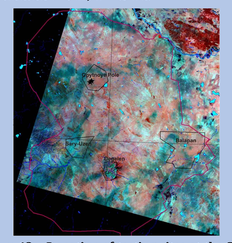
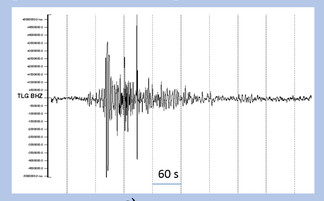


Figure 12a. Location of testing sites at the STS.

Figure 12b. Scheme of Opytnoye Polye site.



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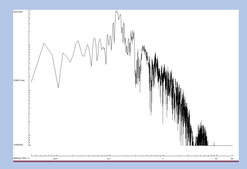

b)

Figure 13. The microbarograph record of the nuclear explosion conducted on November 13, 1962, t0=09-00-17.5, φ=50.4227°, λ=77.7231°, altitude 720 m, Y=4.9 Kt. A) digitized record, b) spectrum.

The digitized historical seismograms and infrasound records are planned to be used for several monitoring tasks: to develop the techniques for source nature discrimination, study of geodynamic processes at Test Sites regions, construction of travel-time curves for Kazakhstan territory, to precise dynamic parameters of nuclear explosions and other.

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