SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

CTBTO
PREPARATORY COMMISSION

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

Aristova I.L.[1], Sokolova I.N.[1], Mackey K.G.[2]
[P2.5-297]

[1]Institute of Geophysical Researches NNC RK, Kazakhstan
[2]Michigan State University, USA

POSTER

IGR

MICHIGAN STATE UNIVERSITY

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

Abstract

We constructed travel-time curves for eastern Tien-Shan using historical seismograms of underground nuclear explosions from the Lop Nor test site in the Peoples Republic of China. We measured the arrival times of the main seismic phases on seismograms from 1969-1996 stored in the analog archives of Kazakhstan as well as digital stations from Kazakhstan and Kyrgyzstan. In total, more than 500 seismograms were processed. The data were used to construct travel-time curves for regional phases Pn, Pg, Sn, Sg, and LR at distances ranging from 700 to 2500 km. Individual travel-time curves were constructed for each event for which the nature of each wave group was précised; a joint averaged travel-time curve for east Tien-Shan using all events was also constructed. The construction of the travel-time curve is used for such tasks as precision of the main parameters of explosions at Lop Nor, improvement of location accuracy of seismic events sources from the east Tien-Shan region (including Lop Nor Test Site area), and other tasks.

The travel-time curve for the eastern Tien-Shan was compared to one in routine use for Central Kazakhstan that was calculated using regional chemical calibration and nuclear explosions conducted on the territory of Semipalatinsk Test Site.

SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
Poster No.: P2.5-297

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

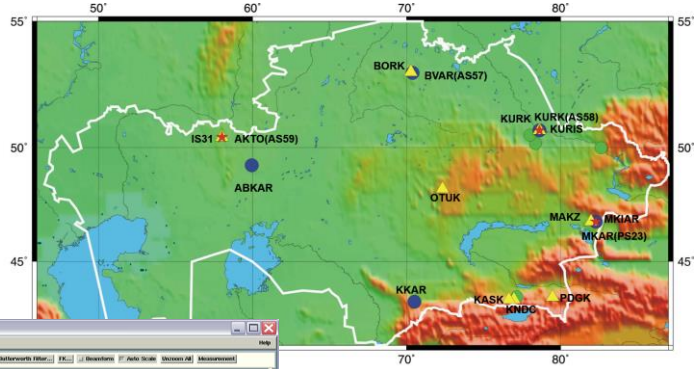
Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

CTBTO PREPARATORY COMMISSION

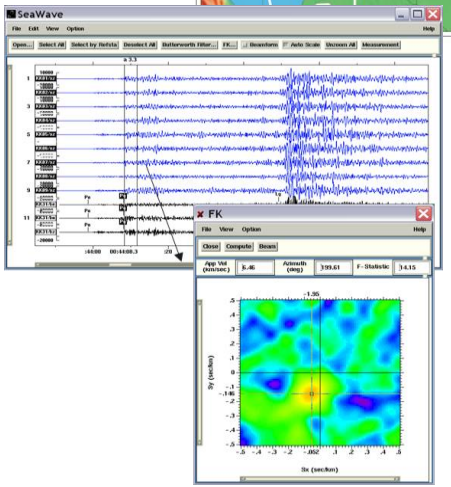
Starting from 1994, a new digital seismic stations network operated by the Institute of Geophysical Research (IGR) of the National Nuclear Center (KZNET) has been operating on the territory of Kazakhstan. Data are acquired, stored and processed by Kazakhstan National Data Center (KNDC).

Currently, for routine processing the KNDC applies the IASPEI91 travel-time curve for events from the region of Central and East Kazakhstan constructed by data of calibration explosions 1997-2000 conducted at the STS territory.

There are a huge number of seismic events recorded by the KNDC from the east Tien Shan region, the most active at the area. For more accurate location of seismic events it is necessary to have a regional travel-time curve constructed using reference events. The underground nuclear explosions records with well-known parameters from the region of the Lop Nor Test Site (LNTS) can be used as reference events.



The IGR NNC RK monitoring network in 2021.



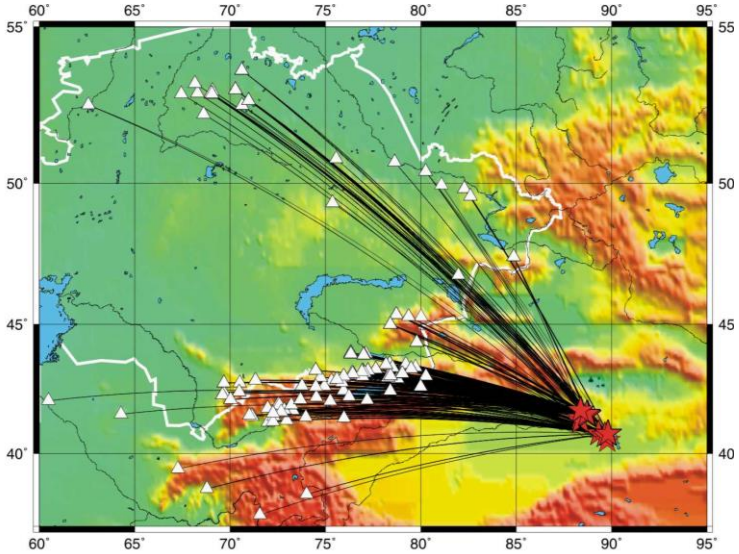
Example of processing by SEATOOLS software

SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
Poster No.: P2.5-297

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

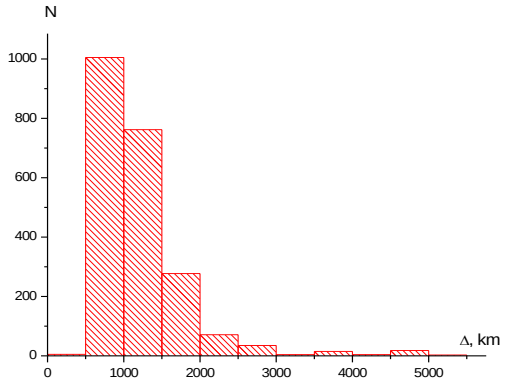
CTBTO PREPARATORY COMMISSION



Map of Central Asia seismic stations that were used for processing (triangles) and explosion epicenters from the LNTS (stars), Kazakhstan boundary (white line)

The LNTS is located in the Xinjiang province (north-west China) about 600 km to the south-east of the Kazakhstan-China border. In 1964-1996, 47 nuclear tests were conducted here.

To compile a bulletin, on the base of which the travel-time curve was constructed, by nuclear explosions conducted at Lop Nor Test Site, the data of historical analog seismograms of the following organizations were used: archive of the Complex Seismological Expedition IPE AS USSR (CSE), Seismological Experience-Methodical Expedition MES RK (SEME), and historical data of digital stations TLG and BRVK, KZNET network data, digital Kyrgyz KNET network, WMQ digital station for UNE of September 29, 1988 for which data are available from the IRIS DMC.



A histogram of epicentral distances from CSE seismic stations to the explosion epicenters at Lop Nor Test Site.

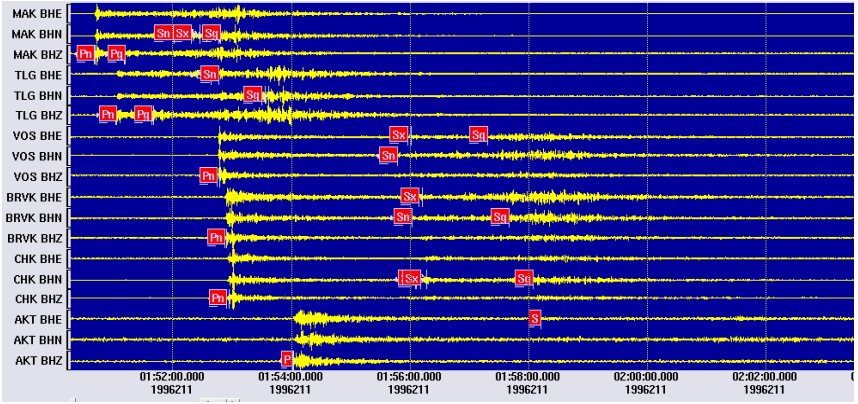
SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
Poster No.: P2.5-297

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

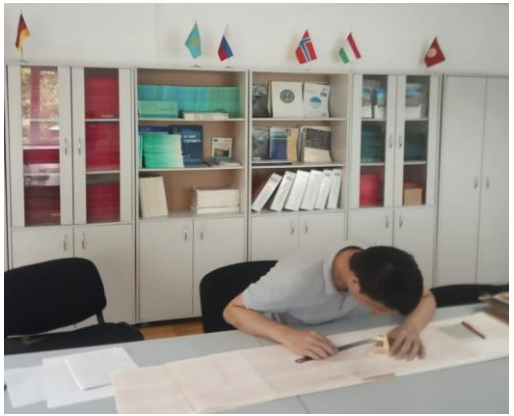
CTBTO PREPARATORY COMMISSION

To create the seismic bulletin we have used the seismograms of nuclear explosions conducted at the LNTS (underground, surface, and atmospheric). Some explosions had no precise coordinates or origin time. For the travel-time curve construction, from the whole database we have selected only those UNE that had accurate origin time and coordinates. The distance range is: for Pn, Pg, Sn, Lg (280-2500 km), for P and S (2500-5300 km).



Seismic records of the UNE conducted at LNTS on July 29, 1996, Y=3 Kt, t_0=01:49:00.17. KZNET network.

Selection of seismograms in the archive of SEME.

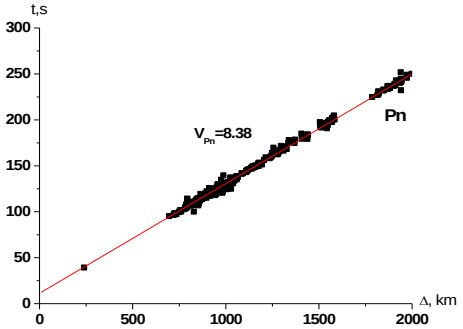


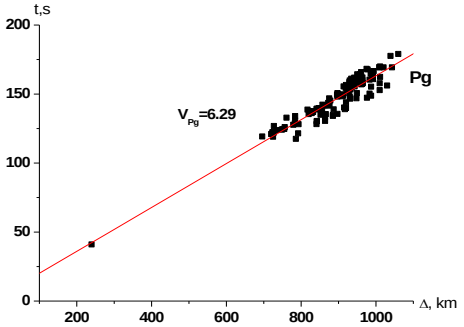
Work with historical seismograms

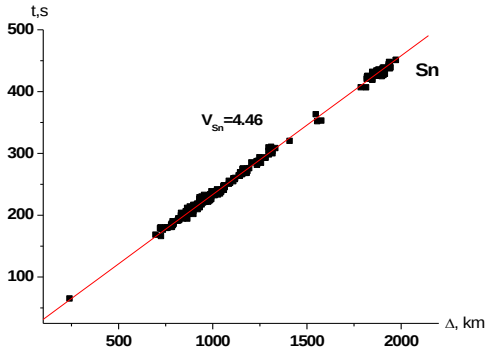
The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

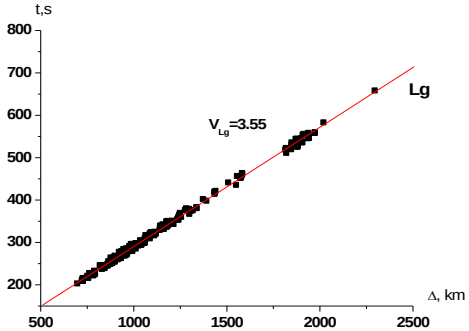
Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

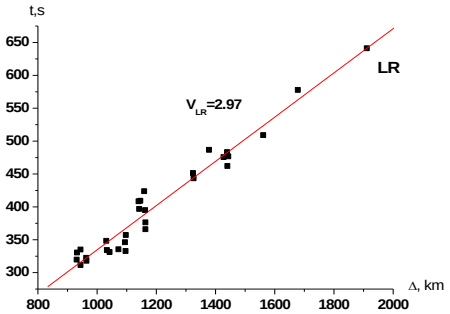
The travel-time curves of the main types of waves using data of nuclear explosions conducted on the territory of LNTS







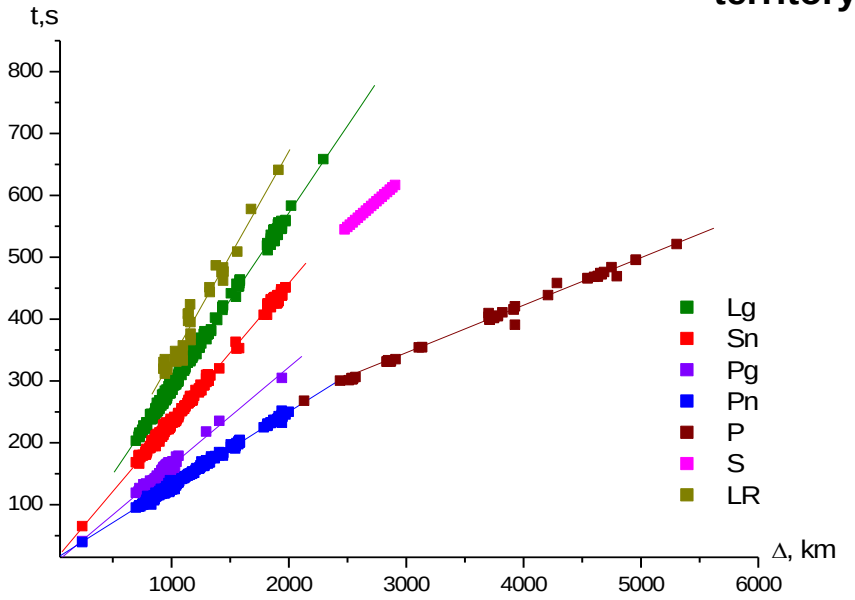




The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

The travel-time curves of the main types of waves using data of nuclear explosions conducted on the territory of LNTS



The equations of the travel-time curves of the main seismic waves

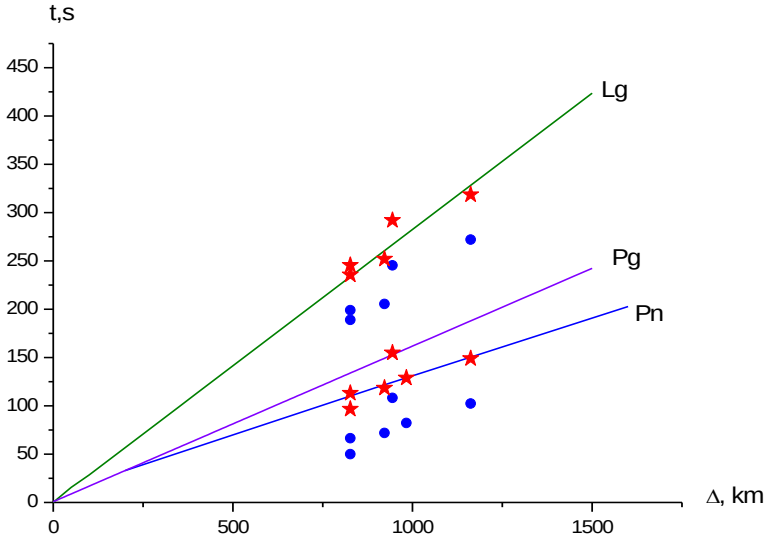
Phase	Distance range	Equation	Velocity
Pn	280-2000	11.305+0.119*Δ	8.379
Pg	280-1000	4.220+0.159*Δ	6.288
Sn	280-2200	9.031+0.224*Δ	4.455
Lg	700-2500	8.611+0.282*Δ	3.551
LR	900-2000	-1.707+0.336*Δ	2.973

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

The obtained travel-time curve can be used to solve a range of tasks, for example, to precise the origin time (t_0) of small nuclear explosions having inaccurate or unknown t_0.

For several explosions having inaccurate t_0, while comparing the measured arrival times of the main phases with the obtained travel-time curve, it is clearly seen that all they are above or below the travel-time curve regression by a constant offset. Considering the obtained correction, t_0 was précised for 6 explosions. As seen, when t_0 was recalculated, all arrival times of the main phases coincide well with the travel-tie curve.



The dependence of travel-time on epicentral distances for the explosion conducted on October 27, 1966.
Blue circles for t_0=01:10:00 from the origin catalog.
Red stars – for the calculated using new travel-time curve t0=01:09:13.37.
Lines – new travel-time curve for the east Tien Shan by data of UNEs from Lop Nor region.

SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
Poster No.: P2.5-297

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

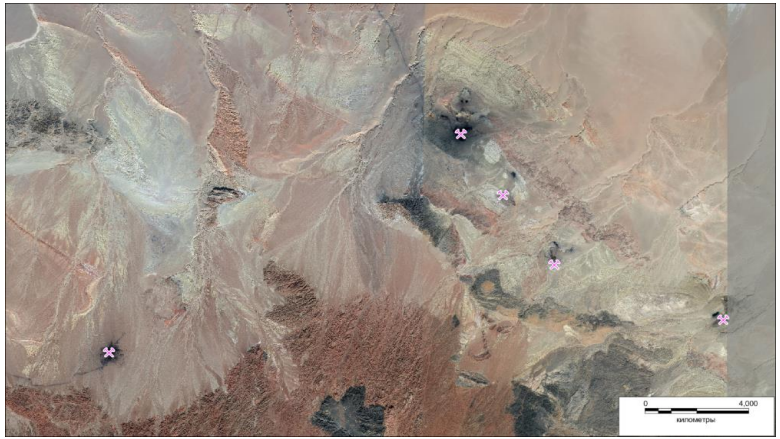
Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

CTBTO PREPARATORY COMMISSION

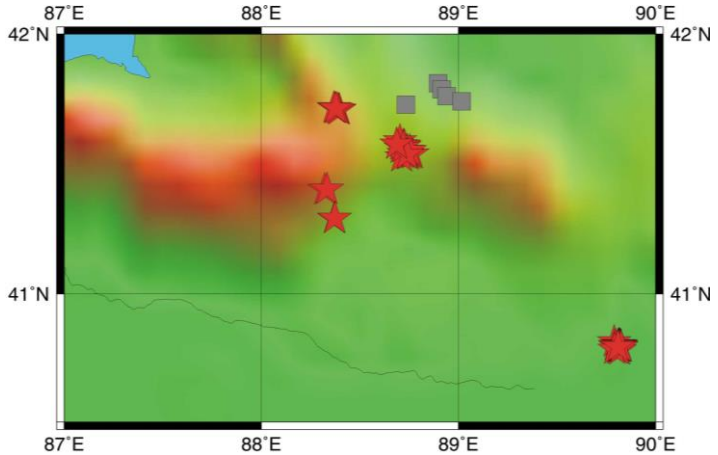
Another task where the new travel-time curve can be used is its application in the routine processing to compile a bulletin of events from the region of the east Tien Shan and its vicinity. To analyze the applicability of the new travel-time curve we need reference events, for example, quarry blasts.

While analysis of the seismic events catalogue from the Lop Nor region we have revealed a lot of events similar to quarry blasts. The analysis of the satellite imagery for the investigated territory has shown the presence of active coal quarries.

The seismic events, assumed to be from the quarries, were analyzed. To answer the question if these are quarry blasts, we have analyzed the proximity of coordinates obtained while location to the quarries, origin time, event energy, and peculiarities of the wave pattern by the closest Kazakhstan stations (Δ~700 km).



Bing Maps image from SASPlanet showing the location of active coal quarries near the LNTS where currently the industrial blasts are conducted. The quarry locations are shown with crosses.



Map of nuclear explosion epicenters from the LNTS (stars), coal quarries (grey square).

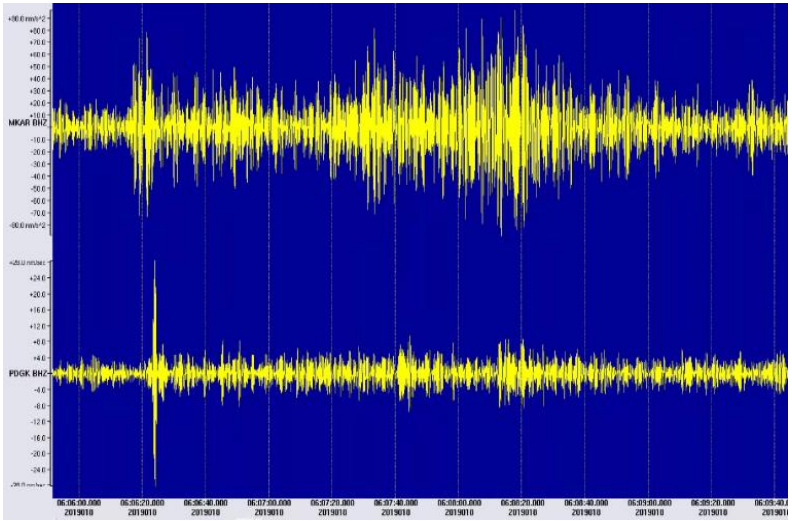
SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
Poster No.: P2.5-297

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

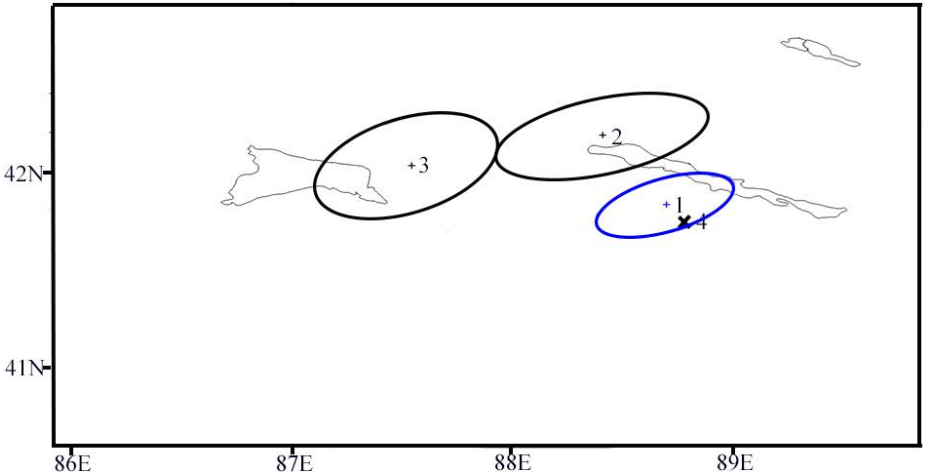
Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

CTBTO PREPARATORY COMMISSION

Quarry events were relocated using different travel-time curves: for Central Kazakhstan, IASPEI, and new travel-time curve. A depth of 0 km was fixed for calculations. The new travel-time curve improved the accuracy of the events epicenters determination and made smaller the error ellipses of location.



Seismograms of a presumed quarry explosion conducted on January 18, 2019 showing stations PDGK and MKAR. Records are Z-component and high-passed filtered from 2.5 Hz.



The epicenters and error ellipses for the explosion of January 18, 2019 relocated using 1 – travel-time curve of the east Tien Shan, 2 – travel-time curve for Central Tien Shan, 3 – IASPEI travel-time curve. 4 – coal quarry.

The travel-time curve for the region of the east Tien Shan by the records of historical seismograms of UNE from the Lop Nor Test Site area

Aristova I.L. (i.aristova@kndc.kz), Sokolova I.N. (sokolova@kndc.kz), Mackey K.G. (mackeyke@msu.edu)

Conclusion

The current work demonstrates how important it is to save the historical seismograms stored at the archives of different seismological organizations. They allow revealing and processing of such events that until recently were absent in the catalogs, for example, weak nuclear explosions, or reprocess and better precise historic events. The characteristics of old records can be used to solve different tasks, one of them is presented in this work – construction of a travel-time curve for regional phases of the east Tien Shan using data of underground nuclear explosions conducted at the Lop Nor Test Site. The travel-time curve was constructed for the basic regional phases Pn, Pg, Sn, Sg in the distance range 300 – 2500 km. The records for 1969-1996 were collected from four different archives and systematized – IGR NNC RK, CSE IPE AS USSR, SEME MES RK, and IRIS DMC. The obtained travel-time curve allowed precising origin time t_0 for small historical nuclear explosions, and enhances the accuracy of epicenter determination in the Tien Shan region of Central Asia.

The authors acknowledge the SEME MES RK for the opportunity to use the archive of historical seismograms for investigations, and IRIS DMC for providing data of KNET stations and CD. This project was funded by the United States Department of State, Bureau of Arms Control, Verification, and Compliance through contract 19AQMM18P1797 issued to Michigan State University.