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LARGE CHEMICAL EXPLOSIONS OF THE SOVIET PERIOD ON THE TERRITORY OF KAZAKHSTAN AS GROUND TRUTH EVENTS

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[P2.5-176]

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POSTER

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Large chemical explosions of the Soviet period on the territory of Kazakhstan as ground truth events

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Abstract

In Soviet time, large chemical explosions were conducted on the territory of Kazakhstan with different purposes (industrial, investigative, military). The parameters of these explosions are known quite well, but can be précised by special investigations using contemporary methods. Further these explosions can be used as ground-truth events for the calibration of the regional seismic networks in Central Asia.

These explosions are: 1 – investigative explosions in the south of Kazakhstan, Arys 19.12.1957, yield 1000 t; 2 – double explosions for construction of a mud dam near Almaty: Medeo 21.10.1966, (1689 t and 3604 t) and Medeo 14.04.1967 (3940 and 1944 t); 3 – investigation explosion “Massa” near Almaty, 28.11.1981 (251 t); 4 – investigative explosions in Central Kazakhstan of 9 ton yield Chemex-1 2.09.1987 and Chemex-2 3.09.1987. In addition, on the territory of Semipalatinsk Test Site there were 175 chemical explosions conducted for military and scientific purposes; the parameters are known for ~30 explosions.

For these explosions, using the archive and published data, the source parameters were précised, the catalogue and seismic bulletin were compiled. The kinematic and dynamic parameters of records were investigated, regional travel-time curves were constructed. The seismic effect of the investigated explosions was compared with that of other large chemical explosions conducted on Central Asia territory.

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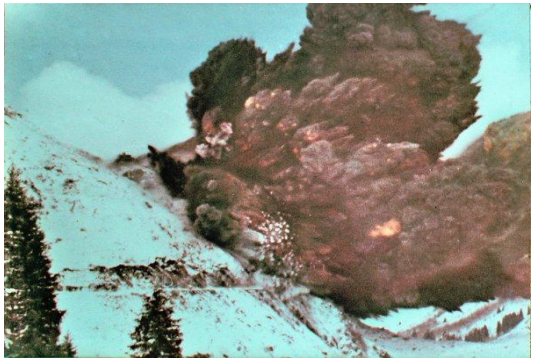
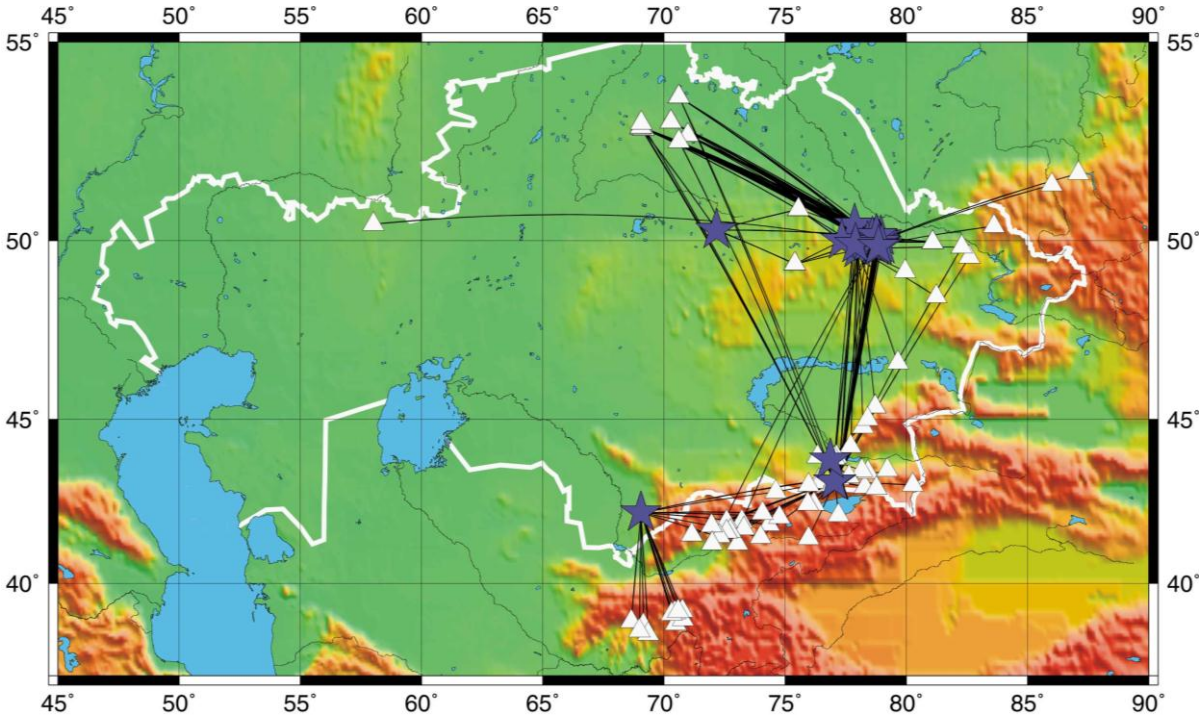
At the present time, there is growing interest to saving and using of the historical seismograms of nuclear explosions, and the seismograms of large chemical explosions with well known parameters are also of high value. Its data can be used in the tasks of seismic discrimination, study of lithosphere structure, construction of regional travel-time curves, investigations of seismic effects, modeling of future calibration explosions and other.

In Soviet era, on the territory of Kazakh SSR, huge amount of large chemical explosions were conducted for different purposes, construction of dams, research and other.





The map of seismic stations (triangles) location and epicenters of large chemical explosions (blue stars) on the territory of Kazakh SSR.

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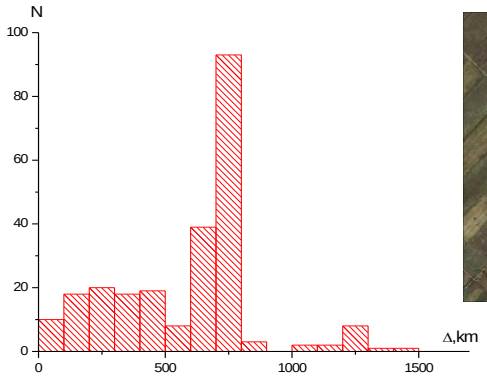
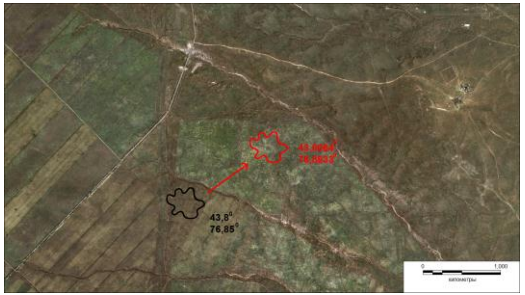
For the investigation we have selected historical seismograms of chemical explosions from the archive of the CSE IPE AS USSR for 1957-1988 and temporary seismic stations installed during the experiments. The arrival time of the main regional phases, amplitudes and periods were measured. In total, ~300 seismograms were processed for epicentral distance from 0.8 km to 3560 km. A range of analog seismograms was digitized. The literature and fund works were collected. For more precise determination of nuclear explosions coordinates at the sites the satellite images of SASPlanet of high resolution were used.

The work on seismograms selection in the archive of CSE.

Work with historical seismograms.



A histogram of epicentral distances distribution of chemical explosions seismograms from the CSE archive



Example of coordinates precision for “Massa” explosion near Almaty, 28.11.1981 (251 t)

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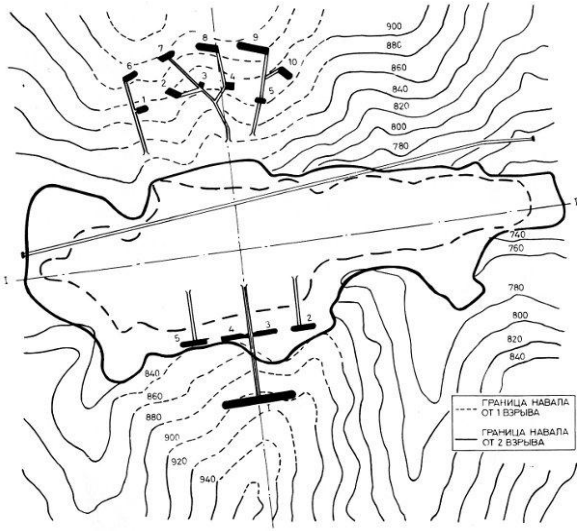
Examples of chemical explosion records application for different tasks by the example of explosions for the mudflow dam construction at Medeo, 1966-1967.

One of the most dangerous natural phenomenon on the number of destructions and victims at the submontane territory of Almaty and Almaty region is the mudflow. To protect Almaty against the mudflows, the project on fill dam creating at Small Almaty river gorge using pin-point blasts was adopted.

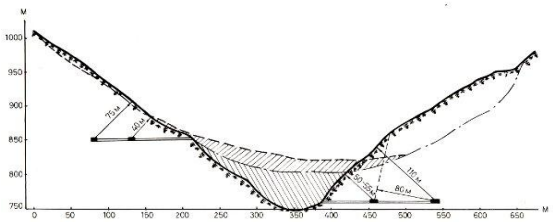
The first series of explosions (right bank) was conducted on October 21, 1966. It contained several charges. The charge exploding was conducted with 3.56 s delay. First, the charges having the total weight of 1689 t located in 4 chambers were exploded. After that the main charge of 3604 t was exploded.

The second explosion (left bank) was conducted on April 14, 1967 and consisted of 2 sequences of charges the total weight of which was 3940 t. The first contained five charges with the total weight of 1117 t, the explosion was simultaneous. The second explosion had five charges and its weight was 2825 t, it was conducted in 2.2. sec after the first one.



The plan of charges location and contours of the rock destruction during the explosions at Medeo.

The first pin-point blast of October 21, 1966.



The cross-section of the gorge on the dam axis before and after the explosion

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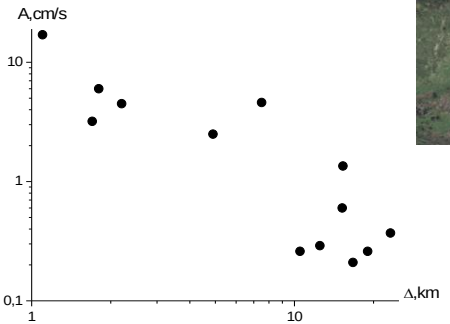
Parameters of explosions at Medeo

Date	t0	Lat., N	Lon., E	mb	Yield, t	Number of charges
21.10.1966	04:59:59.1	43.1512	77.0665	5.2	1689	4
21.10.1966	05:00:02.7	43.1513	77.0676	5.3	3604	1
14.04.1967	05:00:08.6	43.1514	77.0589	5.0	1121	5
14.04.1967	05:00:10.8	43.1514	77.0582	5.0	2825	5
20.11.1973	05:00:21.5	43.1467	77.0575		200	

To investigate the seismic effect of explosion, assess the size of seismic dangerous zone and to reveal the regularities of points change with distance, some seismic observations were conducted. For this purpose, about 100 seismometers and accelerometers of strong motions were installed at distance 0.8-300 km from the explosion. In addition, the explosion was recorded by a lot of permanent seismic stations.



The amplitude values of seismic effect on distance for the first series of explosions in 1966.

The space image of the mud flow dam and location of explosions, 21 October 1966, 14 April 1967, 20 November 1973.

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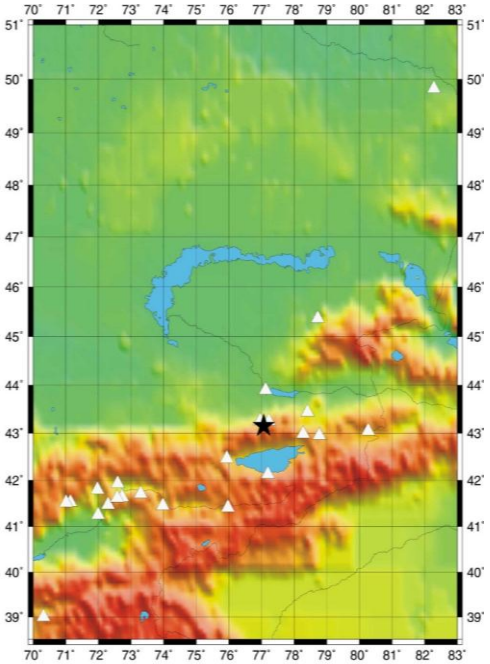
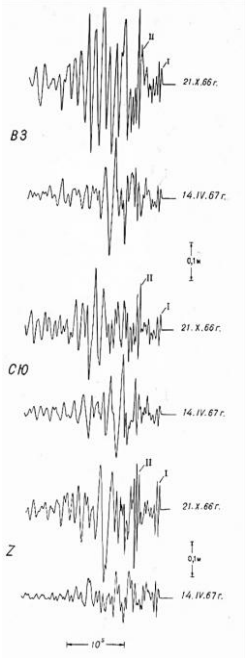
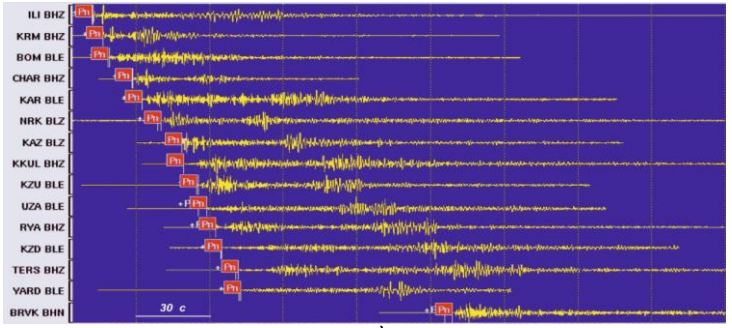


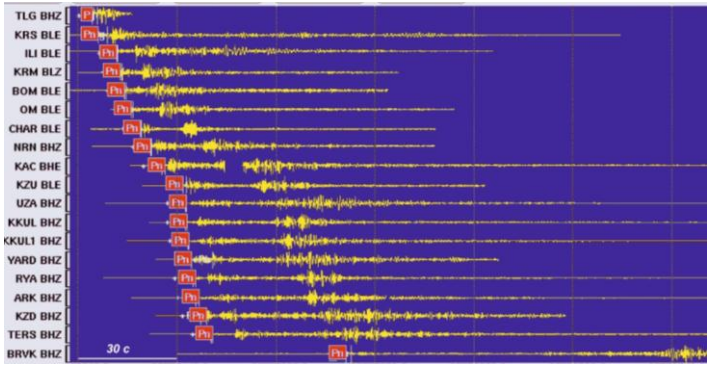
Location of explosions epicenters (star) and permanent seismic stations (triangle) for 21.10.1996.



Seismograms of explosions, 21 October 1966, 14 April 1967 at Medeo. Talgar station (from CSE archive).



a)



b)

The digitized seismograms of explosions at Medeo: a) 21.10.1966, b) 14.04.1967. Z-components, and E-W components for seismograms which vertical components could not be digitized.

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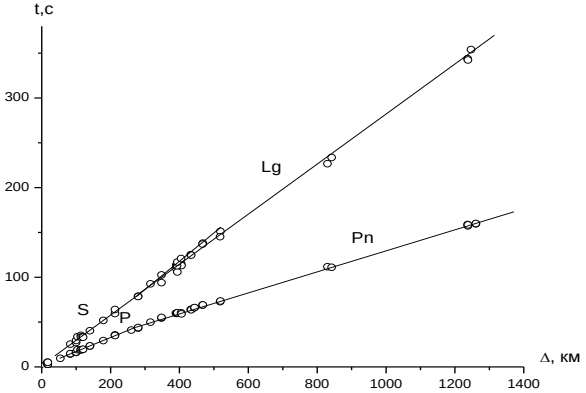
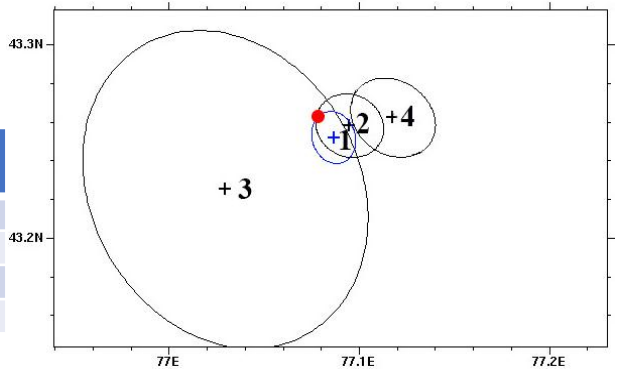
A new travel-time curve for Almaty and its vicinity was constructed. The travel-time curve was compared with other travel-time curves used for events location at the northern Tien Shan. It was revealed that application of reference explosions travel-time curve shows less sizes of location error ellipses than application of other travel-time curves. The obtained results can be used for seismic events location, design of early warning system for Almaty, for seismic hazard assessment.

The equations of propagation time on distance for the main types of seismic waves for Medeo explosions.

Phase	Distance, km	Travel time	Velocity, km/s
P	10-250	0.268+0.1649*Δ	6.06
Pn	250-1400	13.004+0.117*Δ	8.52
S	10-250	1.181+0.280*Δ	3.57
Lg	250-1400	7.071+0.272*Δ	3.67





Filled circle – reference epicenter of explosion, 19.01.2013, epicenters and error ellipses obtained while using the travel-time curves: 1 – by data of Medeo calibration explosions, 2- Central Kazakhstan, 3- CSE IPE AS USSR, 4- Sabitova T.M. For the northern Tien Shan

The travel-time curve by the results of Medeo explosions recording .

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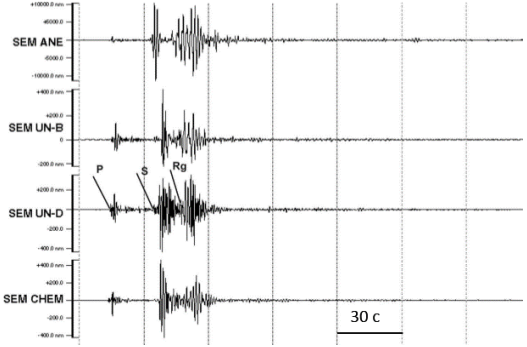
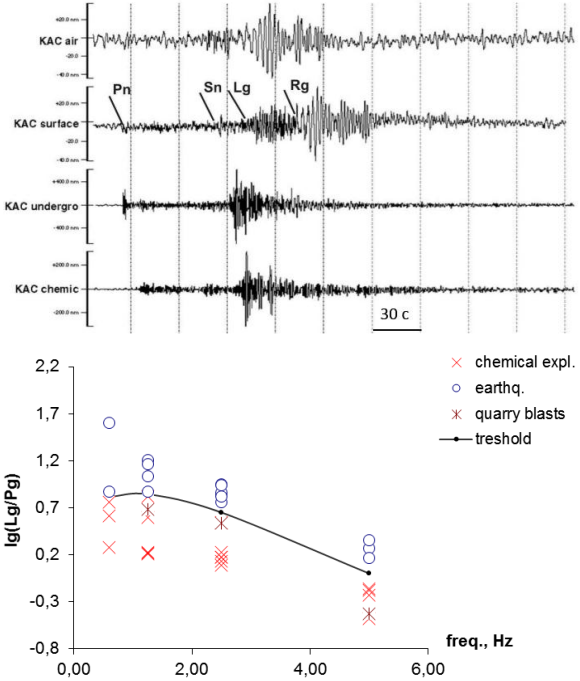
Examples of chemical explosions records application for different tasks by example of explosions conducted at the STS in 1961-1988.

175 chemical explosions were conducted at former Semipalatinsk Test Site (STS) with military or research goals; unfortunately we were not able to collect information on all explosions, 29 chemical explosions only recorded by the seismic stations network of CSE IPE AS USSR in 1961-1988 are well described [Khalturin et al, 2001].

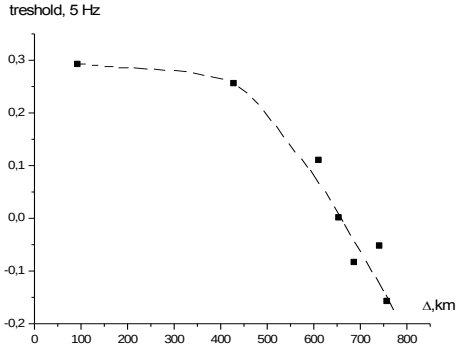


The different type explosions at the STS by SEM station (Δ~170 km). Top-down: seismogram of air nuclear explosion, underground nuclear explosion in the borehole at Balapan site, underground nuclear explosion in a tunnel of Degelen site, chemical explosion at the STS. SKM filter. Z –channel.



Distribution of Lg/Pg ratio for chemical explosions and earthquakes at the STS. Borovoye station, Z-channel.

The different type explosions at the STS by KAC station (Δ~ 500 km). Upper seismogram– air nuclear explosion, second upper seismogram – surface nuclear explosion, third upper – underground nuclear explosion in a tunnel of Degelen site, lowe – chemical explosion at the STS. Z-channel.



Dependence of threshold value for Lg/Pg ration in filter 5.0 Hz, Z-channel, on average epicentral distance to the Semipalatinsk Test Site.

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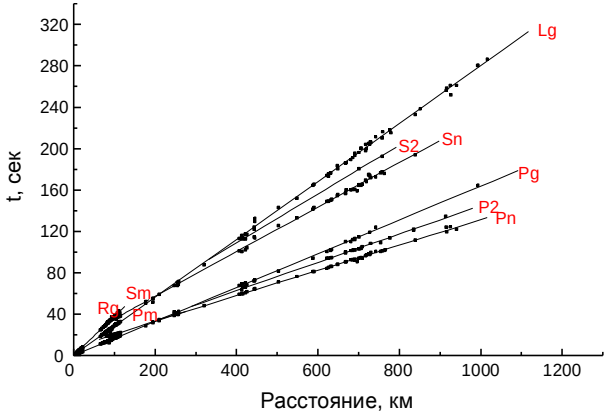
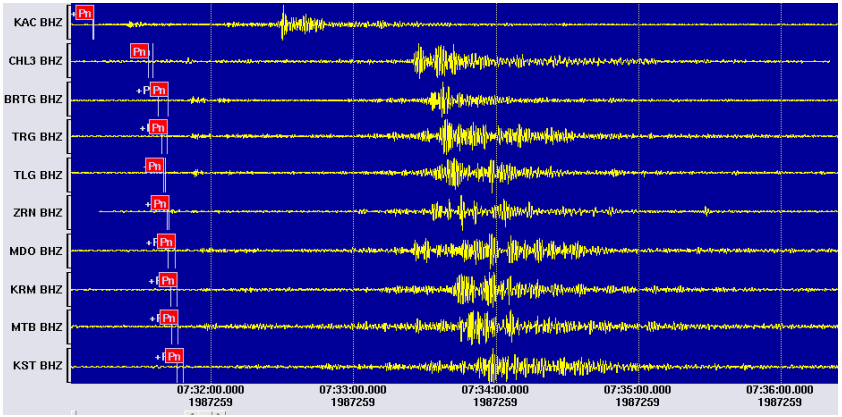


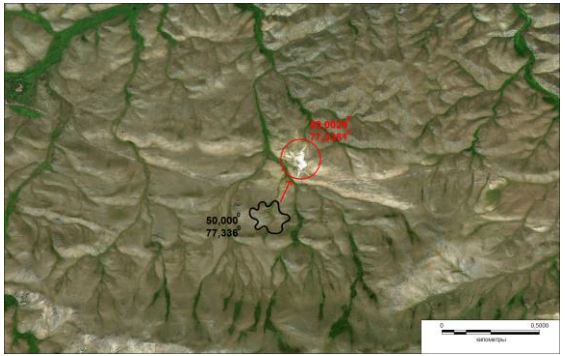
The cumulative travel-time curve by the results of calibration chemical explosions recording at the STS.



Explosion seismograms, 2 September 1987, t0=09-27-4.95. Murzhyk site, STS.

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

Phase	Distance, km	Equation
Pn	200 – 1500	9,55 + 0,12 · Δ
Pg	0-30	0,12 + 0,18 · Δ
	30-1050	0,57 + 0,16 Δ
Sn	200-1500	14,13 + 0,22 Δ
Lg	0-30	0,09 + 0,31·Δ
	30-1500	0,31 + 0,28 Δ



Precision of the explosion location, September 2, 1987, t0=09-27-4.95. STS, Murzhyk site.

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For all chemical explosions, the magnitudes mb, mpv and energy class K (Rautian) were calculated.

To calculate the energy class of an event, the peak amplitude in P- and S-phases of seismic waves at the short-period channels of SKM type were used. Further, the calculation was conducted by formula

$$K=1{,}8\ lg(A_p + A_s) + \sigma_1(\Delta),$$

where A_p and A_s – peak amplitude of P and S – waves in microns; $\sigma_1(\Delta)$-calibration function for $A_p + A_s$ in distance range from 10 to 3000 km.

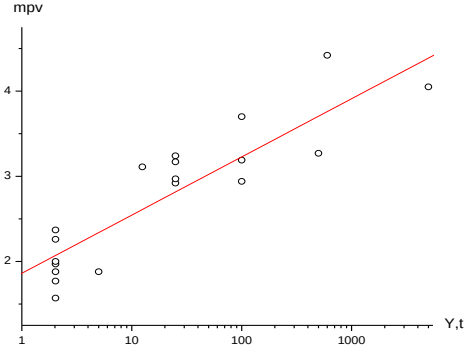
For mpv determination, the amplitude and period of P-phase for the time moment was determined when the oscillation velocity is maximum. The mpv value was calculated by formula

$$mpv = lg\ (A/T) + \sigma_2(\Delta), \quad (2)$$

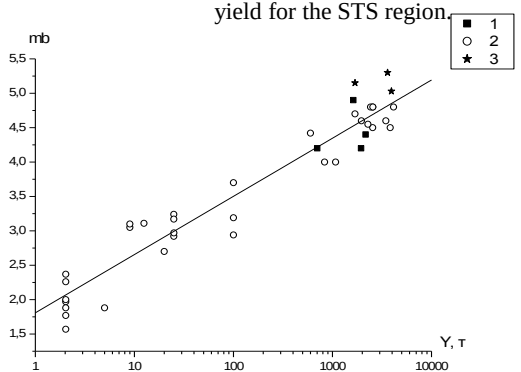
where A and T – amplitude and P-wave period, $\sigma_2(\Delta)$-calibration curve in distance range from 10 to 1000 km.

Dependence of chemical explosions magnitude at the STS on the yield can be expressed by the following relation:

$$lg(Y)=1.86+0.68*mpv, \quad R=0.89.$$



Dependence of mpv magnitude of chemical explosions on yield for the STS region.



1 – large industrial/research explosion on Central Asia territory, 2 – Baypaza, Byurlykiya, Uchterek, Kambarata, 3 – Medeo.

Dependence of mb magnitude on explosions yield

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Conclusion

The work shows the examples of application of historical materials on the reference chemical explosions for different monitoring tasks:

- **Obtaining of new velocity models for the territory zoning by velocity characteristics. This will help in enhancing the monitoring effectiveness of seismic events the important part of which is location of signal sources recorded by seismic stations.**

- **Seismic discrimination of events nature.**

- **Investigation of explosion magnitudes on yield.**

- **Investigation of seismic effects of large explosions on urban areas and other.**