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Application of Kazakhstan monitoring network data for the safety of nuclear facilities #177

Irina Aristova, Inna Sokolova, Alexander Velikanov, Alexander Sokolov

[P5.2-177]

POSTER

Institute of Geophysical Researches NNC RK, Kazakhstan

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Abstract

In Kazakhstan, from 1994 the NNC RK operates the contemporary monitoring system that includes seismic stations. 4 stations are included into the IMS: PS23, AS57, AS58, AS59. The main goal of NNC RK network is monitoring of nuclear explosions in support of the CTBT. The data of NNC RK network are actively used in civil tasks, for example, to estimate the seismic hazard of places where the nuclear critical facilities are located. Kazakhstan possesses the research nuclear reactors, LEU bank, tailing facilities, Tokamak, infrastructure of the Semipalatinsk Test Site, the nuclear power plant is planned to be constructed in future. All these facilities are located in tectonically different regions of Kazakhstan. The seismic hazard of many Kazakhstan regions was poorly investigated and, as a result, underestimated. The contemporary data of NNC RK network and archive materials were analyzed and generalized, the earthquake catalogues were created for the regions where nuclear facilities of RK are located. The tectonic structure was studied, the database of strong motions was created, and the seismic hazard of the regions was estimated. The necessity to create the early warning system for earthquakes at the regions of the research nuclear reactors location is shown.

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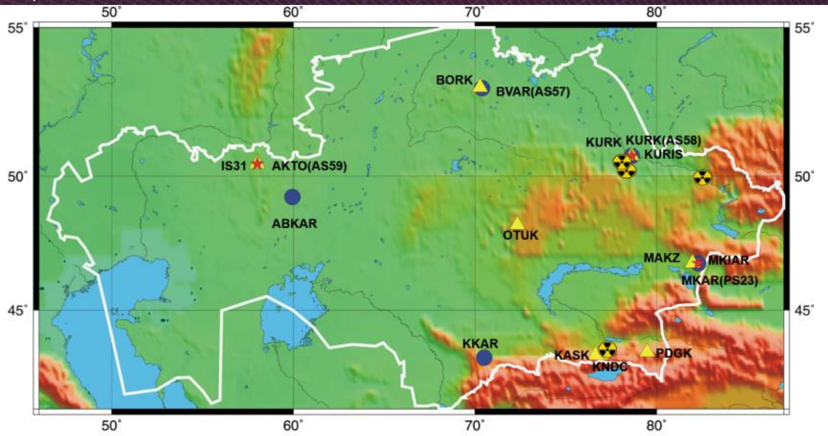
The main dates of the IGR ME RK observation system installation:

1994 – The stations of special control service of the former USSR – Borovoye, (BRVK) Kurchatov (KURK), Aktyubinsk (AKTK/AKTO), Makanchi (MAKZ) were transferred to the NNC RK.

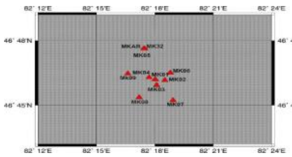
- 1994 – installation of 8 broadband digital stations on the territory of Kazakhstan together with LDEO (AKTK, BRVK, CHKZ, KURK, MAKZ, TLG, VOS/VOSK, ZRNK).
- 1994-1996 – installation of 3 stations of IRIS/IDA and IRIS/GSN system (Borovoye, Kurchatov, Makanchi) in Kazakhstan.
- 1996 – Kazakhstan signed the Comprehensive Test-Ban Treaty according to which the installation of 5 IMS facilities on the territory of Kazakhstan is planned.
- 1997 – installation of three-component seismic stations Podgornoye (PDGK/PDGN), northern Tien Shan.
- 1999 – opening of the Centre for acquisition and processing of data (KNDC) in Almaty.
- 1999-2000 – construction and launching of the primary IMS Makanchi station PS23 (MKAR). The station was certified in January 2002.

BVAR- AS057 seismic array

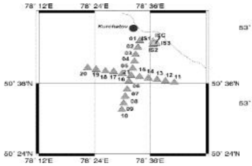
- 2000 – 2001 – construction and launching of Karatau (KKAR) station (AFTAC).
- 2001-2002 – construction and launching of the auxiliary IMS Borovoye AS057 (BVAR) station. The station was certified in December 2002.
- 2001 – construction and launching of Aktyubinsk infrasound station (IS31). The station was certified in November 2004.
- 2002-2003 – construction and launching of Akbulak station (AFTAC).
- 2005 – modernization and launching of auxiliary IMS station, Aktyubinsk AS059 (AKTO). The station was certified in November 2005.
- 2006 – launching of three-component KNDC station located in Almaty.
- 2006 – launching of auxiliary IMS station, Kurchatov-Cross AS058 (KUR01-KUR21). The station was certified in 2007.
- 2010 – launching of three-component Ortau station (OTUK) located on the territory of Central Kazakhstan, and modernization of three-component Podgornoye station (PDGK/PDGN), Northern Tien Shan.
- 2016 – launching of three-component seismic station Kaskelen (KASK) westward of Almaty city.



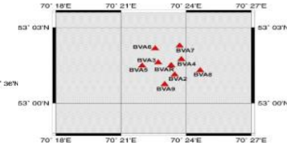
The map of IGR RK seismic stations location and communication scheme (8 seismic arrays, 7 3-components stations).



MKAR-PS23 seismic array



KURK – AS58 teleseismic array



BVAR- AS057 seismic array

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Research nuclear reactor WWR-K (Almaty city)

Research nuclear reactor WWR-K at INP (Almaty, population ~2 million) was launched in 1967; it worked on thermal capacity of 10 MWe till 1988 without deviations from the normal modes. From 1988 to 1998 works on safety strengthening in conditions of high seismicity (calculations and substantiations, strengthening of designs, duplication of the systems responsible for the safety, registration of the new documentation) have been spent. By the configuration change of the active zone, the thermal capacity has been reduced to 6 MWe without loss of neutron flows. On the basis of the reactor, besides the fundamental nuclear-physical researches and the researches of material science and reactor tests, works on the manufacture of medical radioisotopes and gamma sources, neutron alloyage of silicon, neutron-activating analysis are carried out.

Research nuclear reactor WWR-K

Entry of first part of uranium to the IAEA LEU Bank.

Low-enriched uranium repository – IAEA LEU Bank was created on the base of Ulba metallurgic plant near Ust-Kamenogorsk and is operated under the guidance of the International Atomic Energy Agency (IAEA) and is a storage for uranium hexafluoride – raw material used for production of fuel pellets for NNP. The repository is a building of 900 square meters, non-combustible, earthquake-resistant, with small administrative room for the IAEA staff.

The pulse research reactor IGR and water-cooled reactor IVG.1M IAE (Semipalatinsk Test Site territory, East Kazakhstan (STS)).

IGR Reactor

One of the oldest research reactors in the world, IGR reactor is a unique source of neutron and gamma radiation characterized by a high dynamics of power change. I
GR reactor nuclear safety is specified by a considerable level of negative reactivity coefficient that provides guaranteed shutdown of any physically possible power impulse, initiated by positive reactivity insertion through CPS (control and protection system) rods removal.
Among pulse reactors, IGR reactor has the highest fluency of thermal neutrons and integral gamma radiation dose in the experimental cavity of 228 mm in diameter and 3825 mm high.

Reactor Hall

The Reactor View on the Reloading Machine Side

IVG.1M reactor (Baikal-1)

IVG.1M research reactor is an upgraded version of IVG.1 reactor used for tests of fuel assemblies (FA) and cores of high temperature gas-cooled reactors including nuclear jet propulsion (NJP) reactors and nuclear power propulsion plants (NPPP).
IVG.1M reactor can be used in tests providing solution of the following tasks:

- testing of different type FA under operating conditions;
- FA structure material reactor tests;
- testing of FA structures and their elements;
- study of possible accident conditions and testing of preventive measures.

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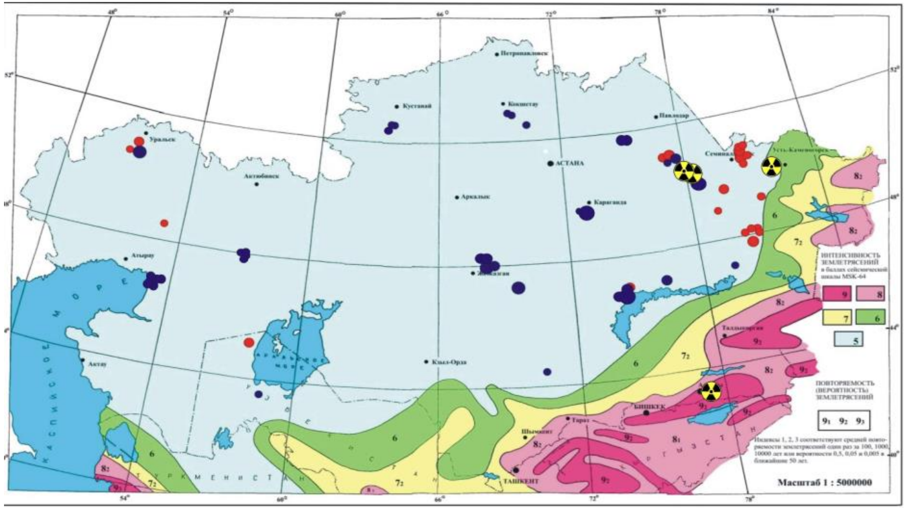
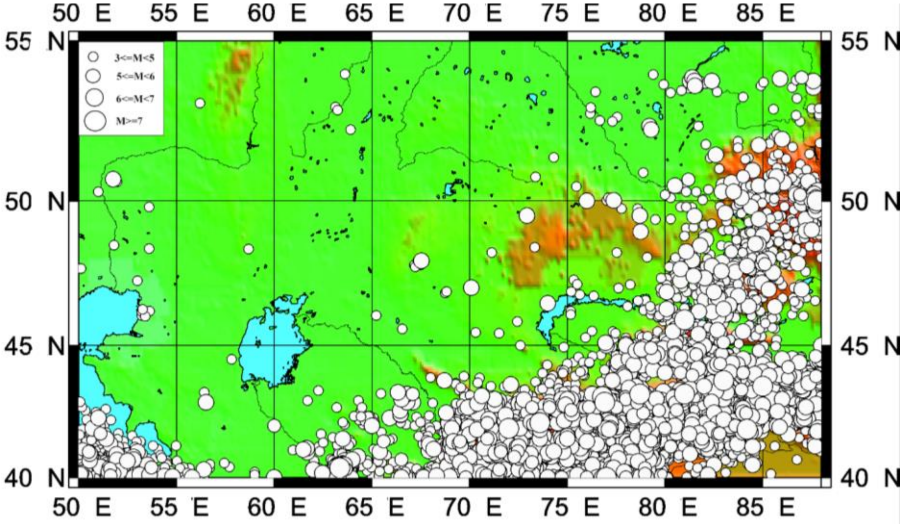
Location of nuclear facilities on the map of general seismic zoning of RK (2006)



The map of earthquake epicenters from historical time (2000 B.C.) to 2020 having magnitude more than 3. The catalogue was created by the IGR NNC RK (number of events >12500).



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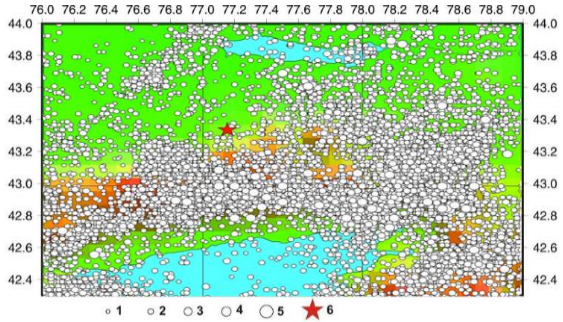
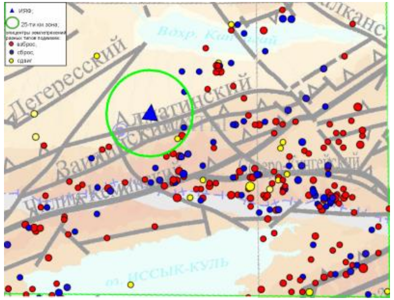
Research nuclear reactor WWR-K (south-east of Kazakhstan)

On the base of the IGR NNC RK network data and literature sources we have created a database on seismicity, geological and tectonic settings, strong motions, focal mechanisms on the northern Tien Shan as a base of investigations. The seismic hazard of the reactor location region was assessed.

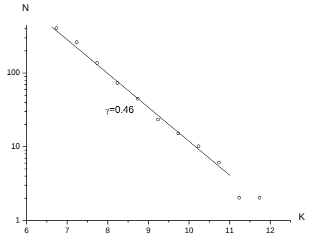


1 - K<6; 2 - 6 ≤ K <8; 3 - 8 ≤ K <10; 4 - 10 ≤ K <12; 5 - K≥12; 6 – location of WWR-K reactor

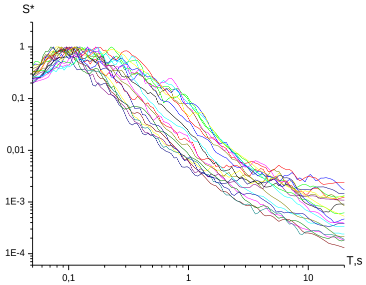
The map of earthquakes epicenters from the northern Tien Shan up to 2020



The earthquakes epicenters (K≥10) with determined focal mechanisms on the map of seismic active faults



The graph of the northern Tien Shan earthquakes reoccurrence for 2020 ($K_P \geq 6.6$).



Normalized acceleration reaction spectrum on horizontal components for WWR-K location site.

The maximum acceleration for seismic generating zones near the WWR-K reactor

Name	Range of hypocentral distances to SGZ, R, km		Mmax	N (reoccurrence of earthquakes with Mmax)	A(K-B), cm/s^2
Iliy		10	5,5	0,002635	220-220
Almaty	10,6	15,4	7	0,000363	236-300
Zailiy	15,2	18,9	8	0,000589	242-275
Kemin	44,6	46,5	8,5	0,001245	148-152

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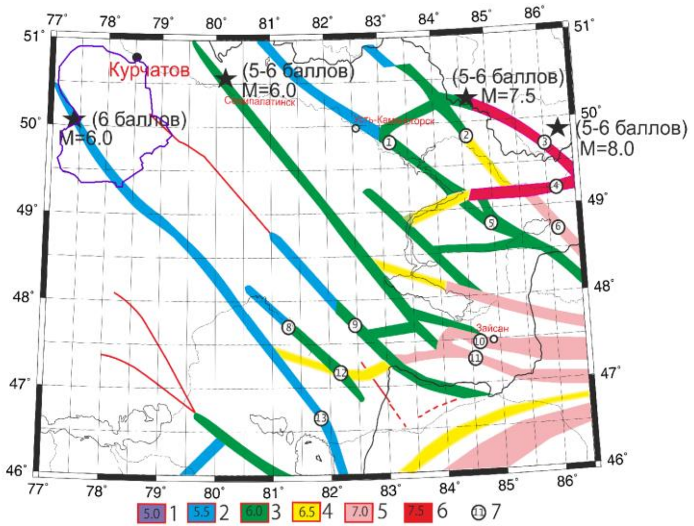
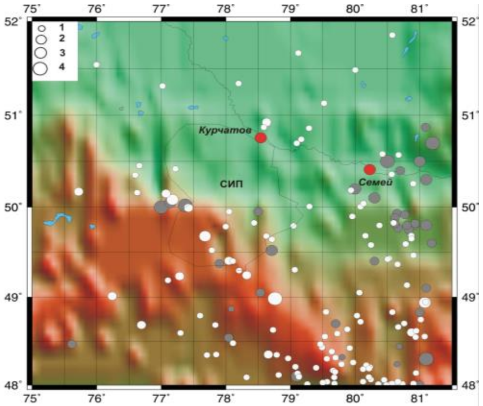
Nuclear facilities at the east of Kazakhstan

A database on seismicity, geological and tectonic settings, strong motions, focal mechanisms for the east Tien Shan was created as a base of investigations. The seismic hazard of the critical facilities located in the east of Kazakhstan was assessed.

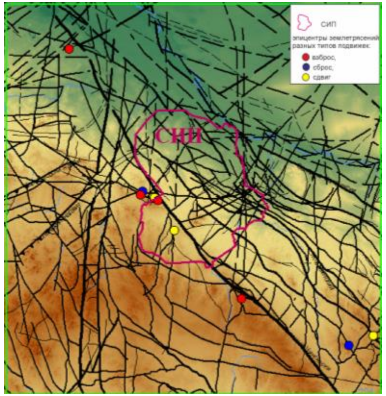


Seismicity generating zones at the east Kazakhstan
(data provided by Timyush A.V., precised by the IR NNC RK)

IGR Reactor, IGR Reactor IVG.1M reactor (Baikal-1) (east Kazakhstan 48 - 52° N, 75 - 81° E)



The map of earthquake epicenters from the STS region and its vicinity, the circle size corresponds to magnitude: 1- mb<3, 2- 3≤mb<4, 3- 4≤mb<, 4- mb≥5. Grey circles – earthquake epicenters up to 2004, white circles – after 2004.



The earthquake epicenters with determined focal mechanisms and type of shift in source (data provided by Poleshko N.N.)

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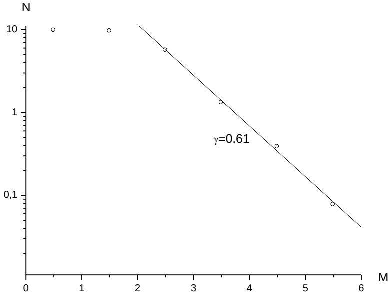
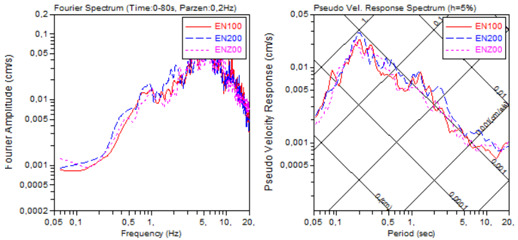
Peak accelerations for seismicity generating zones near the critical facilities of the STS

Name	Epicentral distance from SGZ, R, km to reactor IVG1.M	Mmax	A(Апт), cm/s^2	A(Ф-Т), cm/s^2	A(K-B), cm/s^2
Myurzhyk	60	6	31.37	70.1	23.64
West-Irtysh	150	6	3.92	15.07	5.55
Rakhmanov	450	7.5	4.98	1.93	3.19
Altay	670	8	5.01	0.37	5.42



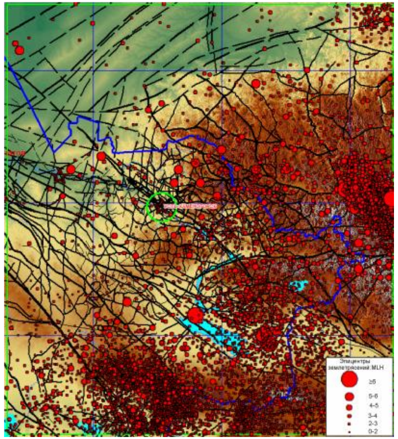
The graph of seismic events magnitudes reoccurrence from the STS region. Period 2004 – 2020.



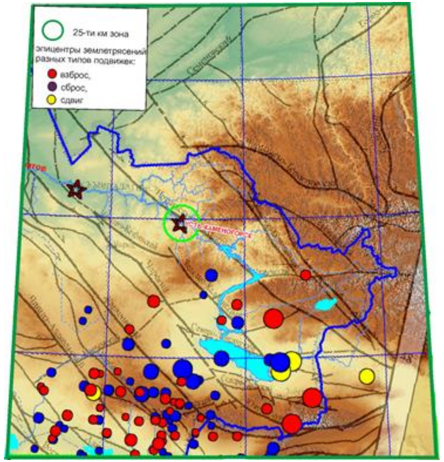
Earthquake response spectra 01/20/2015 at 09:30:56.5, M=5.3. KURK station.

Low-enriched uranium repository – LEU Bank IAEA (east Kazakhstan)

For the seismic safety ensure of the LEU Bank territory, a group of experts from the IAEA conducted a range of works on investigating the geological and tectonic settings, seismicity, parameters of seismic effects, ground conditions and other. The works conducted by the IAEA group on the seismic hazard assessment for LEU bank construction used data on faults, seismicity and focal mechanisms obtained by the IGR NNC RK and IS MES RK.



The map of earthquakes epicenters at the investigated zone of the east Kazakhstan



The earthquake epicenters with calculated focal mechanisms on the map of seismic active faults (data provided by Poleshko N.N.)

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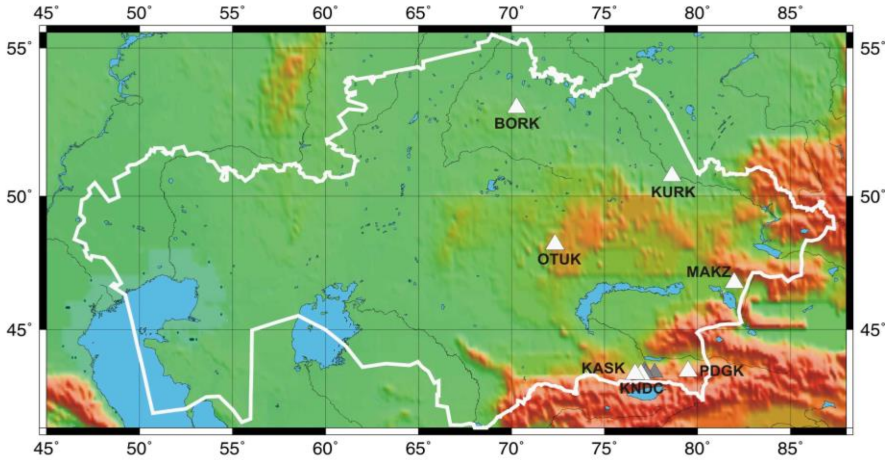
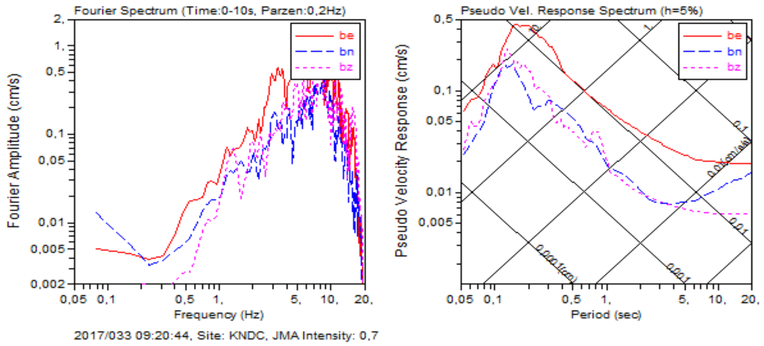
To ensure seismic safety for future critical facilities, it is important to study possible parameters of large earthquakes effects directly on the construction site. For this purpose, the strong motion accelerometers are used. The IGR NNC RK stations network recording strong motions consists of 7 stations located in the south-east (KNDC, KASK, PDGK), east (MAKZ, KURK), north (BORK) and central Kazakhstan (OTUK); in addition, for the investigation tasks, the temporary field stations of strong motions are installed. The strong motions parameters were also collected for stations located in the north Tien Shan by literature sources. The created database contains all data in the unified format. The combined database contains 1140 strong motion records; the maximum acceleration was recorded by Kyurmenty station at distance 35 km away of Baysoryun earthquake epicenter occurred on November 12, 1990, MLH=6.4, Amax=675 cm/s^2.



The map of the IGR NNC RK strong motion stations location. White triangles – permanent stations, grey – temporary stations (2018 – 2020).



Example of strong motion data processing for the earthquake of 02.02.2018 at 09:20:44 (KNDC station)

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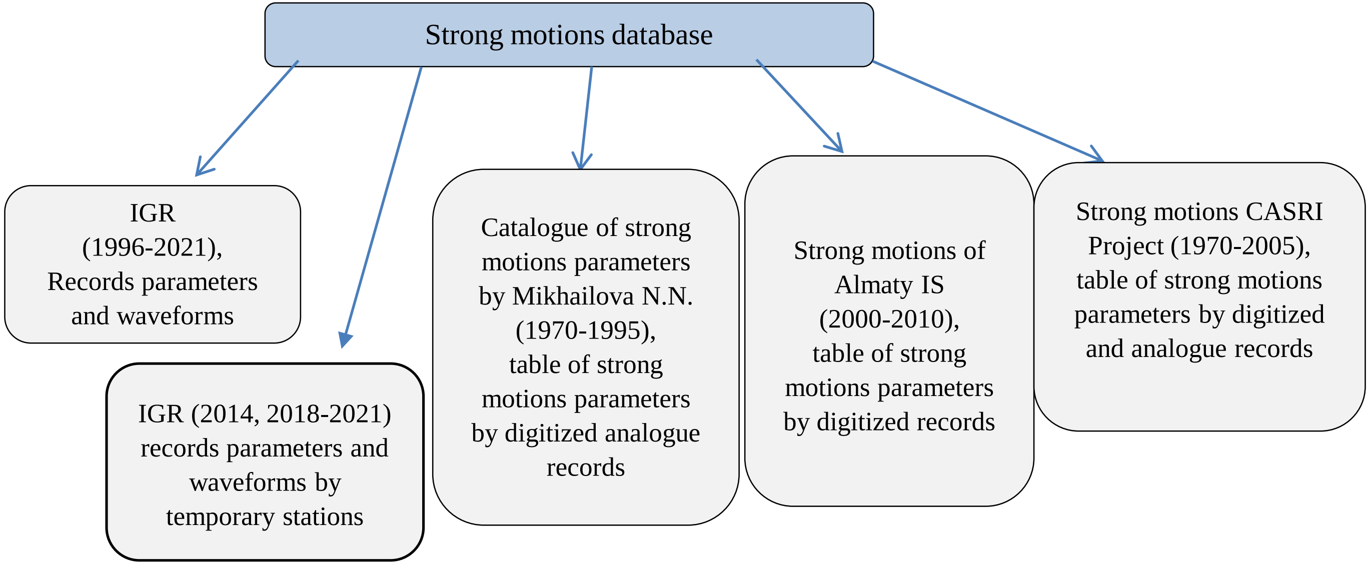
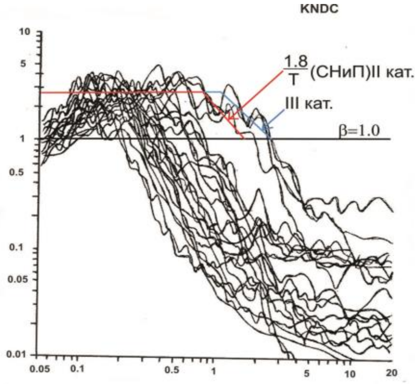


The scheme of strong motions database



Comparison of dynamicity curve by KNDC with the one by Construction Norms and Rules -2006.

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Conclusion

Data of Kazakhstan monitoring network of the IGR NNC RK consisting of 4 stations included into the IMS, in addition to the nuclear tests monitoring tasks are actively used in the range of civil tasks, for example, in hazard assessing of location places of nuclear critical facilities.

For the regions of the research nuclear reactors location, LEU bank and other, the data on seismicity were collected, and the strong motions database was created using data of the IGR NNC RK network data and historical data. The tectonic structure was investigated, the macroseismic data of felt earthquakes were collected, the seismic hazard of regions was assessed.

The necessity to create local monitoring systems as well as early-warning systems on earthquakes at the region of nuclear research reactors location is shown.