136814

UCRL-CR-126766
S/C # B301621

Data Base of Array Characteristics Instrument Response and Data, Recorded at NNC

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December 1996

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National Nuclear Center of Kazakhstan Republic
Institute of Geophysical Researches

**DATA BASE OF ARRAY CHARACTERISTICS,
INSTRUMENT RESPONSE AND DATA,
RECORDED AT NNC**

**(a report of scientific-research work according
to the Agreement N B301621)**

Kurchatov

1996

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List of abbreviations

A/D converter (АЦП) – analogous digital converter (conversion);

AFC (АЧХ) - amplitude frequency characteristics;

AC (AX) - amplitude characteristics;

БИК - pulse calibration library;

TSB (БСВ) - time service block;

GO (ГО) - geophysical observatory;

KAN (КАН) - a commutator of analogous voltage;

KPCh (КПЧ) - low sensitive channel;

MT (МЛ) - magnetic tape;

MCZ (МЦЗ) - magnetic digital record;

NUP (НУП) - unattended remote point;

OMS (ОМС) - a seismic mirror-galvanometer oscillograph ;

PCS (ПЦС) - mobile digital station;

RVZ (РВЗ) - a recorder of visible records;

SG (СТ) - seismic array;

SCR (СЦР) - digital recording station;

UPZ (УПЗ) - the device to view the records;

УПнП - the device to view and to re-write the records;

T- a period between two measurements of the A/D converter;

TSG (ТСГ) - standard seismic array

PFC (ФЧХ) - phase-frequency characteristics;

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1. Introduction.

A northern and east-northern parts of Kazakhstan Republic are utterly favorable for a placing of seismic stations. There is a very low level of natural and industrial seismic noise. Rocks of Kazakh epi-Hercynian platform have a very good transmissive properties.

Geophysical observatories (GOs), now belonging to the Institute of Geophysical Researches of National Nuclear Center of Kazakhstan Republic (IGR NNC RK), were established in especially selected low-noise places of Northern Kazakhstan, in accordance with Soviet program for nuclear weapon tests monitoring. In 1994, these GOs were transferred by Russian Federation into the possession of Kazakhstan. A location of GOs is shown on the Fig 1. According to the studying of seismic noises, jointly implemented by scientists from IGR and IRIS, places, where a 'Borovoye' and 'Kurchatov' seismic stations are located, are among the best places for seismic observations in the world.

Table 1.1

Geophysical Observatories of the National Nuclear Center of Kazakhstan.

Station name	Station code	Latitude (°N)	Longitude (°E)	Elevation	Geological features
Aktiubinsk	AKT	50.433	58.017	400	gabbro-amphibolite
Borovoye	BRVK	53.058	70.283	315	granite
Kurchatov	KUR	50.715	78.621	240	sandstone
Makanchi	MAK	46.808	81.977	600	andesite

A seismic arrays exist in 'Borovoye' and 'Kurchatov' observatories - in two observatories out four ('Aktiubinsk', 'Borovoye', 'Kurchatov' and 'Makanchi'). These two observatories are described in this report.

A history of geophysical observatories, conditions of equipment operations (climatic, geological and so on) are presented in the report, as well as it is described the equipment of GOs and seismic arrays, and samples of digital seismograms, recorded on the equipment of various types, are presented in this report.

GO 'Borovoye' is described in the 2-nd chart, GO 'Kurchatov' is described in the 3-rd chart of the report. The main results of work are presented in the conclusion.

A list of used papers, a list of tables and figures is given in the end of the report.

2. A 'Borovoye' geophysical observatory

Seismic observations at the GO 'Borovoye' were started in 1995, when an expedition in Borovoye settlement of Kokchetavskaya region was organized. This area was chosen for observations because of high efficiency of recording here volumetrical teleseismic waves.

Systems, which had been used in GO 'Borovoye' for a short period of time, just for examination (for example: ASP (АСП), KASS (КАСС), KDSA (КДСА), IP 'Zvezda' (ИП 'Звезда') and so forth) are not presented in this report.

Naturally, the recording equipment, as well as methods of determination of its parameters have been changed during 30 years time period, obeying the general development of techniques. At the beginning, it was used 'classical' equipment of ESSN (ECCH) seismic station with photo-galvanometric type of recording (seismometer - galvanometer). Later on, the recording of data on magnetic tape in digital form was accepted and had been enhanced with the time. The later technique was realized in digital stations KOD (КОД), SCR (СРП), PCS (ПЦС) and so on. The progress of recording equipment of GO 'Borovoye' is shown in table 2.1.

The recording of seismic events on the area of GO 'Borovoye' had been carried out continuously by one or several systems, with the exceptions of separated, short time periods for equipment maintenance. Besides, temporary observations to solve special tasks had been organized on remote points: Jukei, Barmashino, Temir-Tau, Zerenda, Chkalovo and Vostochnyi. The equipment conditions and the main parameters of the equipment had been determined during regular works, with periodicity, depending on given tasks. The main parameters of the equipment here are the following characteristics of seismometrical channel (from a sensor to a recording device): amplitude-frequency characteristic (AFC) and amplitude characteristic (AC), an internal noise of a counting channel, and signal dependencies between channels of devices of the same type. AFC of some counting channels had been changed by sensitivity and by a bandwidth, depending on specific tasks of investigations. As a rule, short-period channels bandwidth was 0.3-5.0 Hz, long-period channels bandwidth was 0.03-0.5 Hz. A range of recording amplitudes for a ground shift was 10^{-5} micron to 5 micron for a short-period channels and 10^{-3} micron to $2 \cdot 10^3$ micron for a long-period channels.

Table 2.1

The progress of the recording equipment of the GO 'Borovoye'

Instrumentation	type of recording	the error of time measurements (sec)	the error of the displacement measurement (%)	dB	the time period of the recording
seismic station	photogalvanometric	0.5	10-20	40	09.1965-10.1972
KOD	digital, magnetic,	0.01	10	60	06.1966-11.1973
	photogalvanometric	0.2	5-10	40	from time to time
SCR-SS (CIP-CC)	digital, magnetic,	0.005	1-5	60	02.1973-12.1989
	photogalvanometric,	0.2	5-10	40	02.1973-07.1981
	visible, pen-ink	0.2	10-20	30	02.1973-12.1989
SCR-TSG (CIP-TCI)	digital, magnetic,	0.005	1-5	60	07.1974 - till present time
	visible, pen-ink	0.2	10-20	30	07.1974 - till present time
PCS-BSG (ИЛС-БСГ)	digital, magnetic	0.005	5-10	66	07.1976-11.1978
IDA-IRIS	digital, magnetic	0.050	depending on speed I	166	09.1994- till present time
БСГ-PASSCAL	digital, magnetic	0.025	depending on speed	140	09.1994 - till present time

2.1 Operating conditions.

All observations points of GO 'Borovoye', except 'Karaganda' (KRG) point, are located in Kokchetavskaya region of Kazakhstan.

The observation area is located on the northern edge of Kazakhstan low hills relief (мелкосопочник) and by geomorphology point of view is consist mainly of accumulate - denudational and half-buried denudational socle plains and low hills, with absolute heights changing from 160 to 500 meters and elevations about 150 - 200 m.

By geology, this area is consist of Paleozoic and under-Paleozoic dislocated rocks, with intrusions of various ages. There are unconsolidated deposits and surface crust of weathering on the surface, consisting of granite rock debris, sands, clays and суглинок, with thickness changing from several meters up to hundred meters. The velocity of longitudinal waves for this layer is $V=0.65 - 2.8$ km/sec. The next layer is consist of slightly jointing (слаботрещиноватый) granites with longitudinal waves velocity $V>3.5$ km/sec.

The general idea about the structure of the earth crust in the area of Kokchetav anticline according to the seismic data is as follows:

'Granitic' layer: thickness - 8-10 km, specific density - 2.67- 2.7 g/sm³, boundary velocity - 6.4-6.5 km/sec.

'Dioritic' layer: thickness about 9 km, specific density - 2.8 g/sm³.

'Basaltic' layer : thickness up to 35 km, specific density - 2.9 - 2.95 g/sm³.

The boundary velocity on the Conrad's discontinuity is 6.9 - 7 km/sec. Moho's discontinuity is found on the depth 52 - 55 km, and its boundary velocity is 8.25 - 8.4 km/sec.

A tectonics of this area is very complicated. Faults and zones of faults of the I (first) order, which are the main part of block tectonics of this area, and which composes the boundaries of blocks of first order, have, mainly, north-western direction. In central and south-eastern part of this area, some of faults are guarded by faults of I order of sub-meridian direction. Faults and zones of the II (second) order, which are the part of blocks of the I order, are of various directions.

According to a data of a gravity and magnetic survey, it is supposed, that all fault structures of I order penetrate through the whole 'granitic' layer, forming boundaries of large blocks in the upper part of the earth crust and displacing the boundaries in basement. The displacements of blocks, caused by faults, are up to 10 and more kilometers in the horizontal direction, and from several meters to several hundreds meters in vertical direction.

It is necessary to note, that granitic layer in the area of observations, often reaches a day surface, so that the surface specific electric resistance of soil at the depth of 1-2 meters varies from several up to

140 000 Ohm*m. In other words, conditions for grounding and lighting protection of equipment here change from favorable to very unfavorable.

The characteristics of seismic noise on 'Borovoye' geophysical observatory had been investigated by records of broad-band seismometer STS-2 with 24-bit A/D converter. A dependence of a spectral density of seismic noise versus frequency (for the frequency ranges from 0.001 up to 100 Hz) is shown on fig. 2.1.

A remote point KRG was located near Temir-Tau town, Karaganda region, in 3 km from Berezniaki village. A geological structure of this area is featured by outcrops on the day surface of a diabase porphyrite, being low-jointing and almost monolithic at the depth of 30-50 meters.

The base point of GO 'Borovoye' is located in Shuchinskii district, in the 4 km from Borovoye village, in the southern shore of Borovoye lake. A disposition of its main technical structures is shown on fig. 2.2.

Seismic sensors had been installed from December, 1965 till 1972, in an adit, located in 60 m to the south-east from the laboratory building N 1, at the elevation of 340 m. There are concrete basements in each chamber of the adit. The doors to the adit lobby and to the corridor are made from metal (one door is an air-tight one). A temperature in the adit chambers during a year changes from 0°C to +8°C (yearly average temperature is + 4.5°C), with the highest temperature in October - November, and the lowest temperature in May - June, whereas the outside temperature changes from -48°C up to +33°C. An air humidity in chambers changes from 85% on winters up to almost 100% on summers during rains. A communication cables from the adit to the laboratory building N 1 are laid in asbestos-cement pipes almost on the surface level . At present the adit is put in the prolonged storage and needs an overhaul repair.

A mine is located between the adit and the laboratory building N 1 at the depth of 15 m from the day surface. It has head cover (оголовок) , shaft, horizontal adit and three chambers. All internal surfaces of the mine are lined with metal casing, to help for a water proofing . During a year a temperature in the mine chambers changes within $+5.2 \pm 0.6^{\circ}\text{C}$. An air humidity in a chamber usually is not more than 80-90%, and it is caused mainly by moisture condensation from an air. A dewatering of chambers and of the adit is carried out regularly with chloride calcium. However, for the last two years, the air humidity in the north chamber heavily increased, because of leak in a ceiling. A communication cables from the mine to the laboratory buildings N 1 and N 2 are laid in asbestos cement pipes. An electric power supply (36 V, 50 Hz) is switched on inside the mine's rooms only during the execution of preventive maintenance. The western chamber is used to place SKM (CKM) and SKD (CKД) sensors of the SCR-SS (CIP-CC) seismic station, the southern - for the KS (KC) and DS (ДC) sensors of the

SCR-TSG (CLIP-TCI) station, and the northern chamber and the adit are used for various experiments.

The holes NN 1-4 are located on an opening in 70-90 meters from the laboratory building N 1 (fig. 2.2). The main information about the holes is given in the table 2.2. All holes, except the hole N3, are covered by metallic pipes with welding (sealed) bottom. A moisture in them is condensed only because of flowing down of condensate. A temperature in the holes during a year changes: at a depth of 45 meter - from +5°C to +7°C; at a depth of 10 meters - from +25°C to +5.5 °C. The hole N 3 is covered by metallic pipe at a depth of a 2-3 meters from a day surface. There is always a water in this hole, at a level of 2 meters from the earth surface. A slag -concrete block head cover (оголовок) is constructed over the hole N 4, to place equipment and power supply in it. Other holes are covered by metallic covers. The communication cables from the holes to the laboratory building s N1 and N 2 are laid at a depth of 30-50 sm in asbestos cement pipes. The holes N 5 and N6 are located at 150 meters to the south from the laboratory building N2, and placed in a deepened equipment construction. The holes N N7-10 are located in 300 meters to the south-east from the laboratory building N2 on a forest glade. The holes N N 5-10 are cased (have casing pipes).

The recording equipment was placed in the rooms of the laboratory building N1. The electric power supply was provided with the direct current from the alkaline battery, and with alternating current (220 V, 50 Hz) from an industrial network. From April 1973, the electric power supply to all main observation services, including the equipment installed on seismic station and SCVN 'Planeta-3' (seismic digital computer 'Планета-3') was carried out by an uninterrupted supply system 2596 and ABP (АБП) (22- V, 50 Hz), with output power accordingly, 4 and 30 kWt [4]. It is necessary to note, that these uninterrupted supply systems have very good reliability. It was only one break-down during 22 years of uninterrupted work. The single disadvantage of this system is poor filtering of high frequencies (tens of kHz), that can cause an interference for a long waves reception. [5].

An observation point 'Jukei' is located in 26 km from the expedition base point, at the foot of the Kirzuha hill, in 1.5 km to the north-west from Jukei village, and 1.5 km to the north -west from Jukei lake. During the 'Jukei' experiment it was constructed from slag blocks a special structure (shelter) at the outcrops of bed rocks to place in it sensors. The recording equipment was placed in a trailer KUNG (КУНГ).

An observation point 'Barmashino' is located in 11 km from the expedition base point, in 1 km to the west from Barmashino village, in 1 km to the north from Shyuchinskii glass plant, and in 150 meters to the west from Shyuchinsk - Borovoye highway.

Table 2.2

Technical specifications of the mines of the mines in the GO 'Borovoye'

observation point	№	factory's number	delivery date	depth (meters)	Diameter(mm), inside, outside	comments
BRV	1	122	03.09.66	50.5	153 168	no casing head-cover
---	2	129	11.11.66	47.0	149 159	
---	3	-	-	53.5	204 216	
---	4	151	24.08.67	44.0	130 140	
BRSh (Barmashino)	1	149	31.07.67	50.0	130 140	head-cover
JK	1	148	17.07.67	51.0	130 140	head-cover
BRV	5	-	12.89	60.0	300 330	structure above the mine
---	6	-	---	60.0	300 330	
---	7	-	---	100.0	300 330	
---	8	-	---	100.0	220 250	
---	9	-	---	100.0	220 250	
---	10	-	---	100.0	220 250	

In 1967, the holes were drilled and head covers (оголовки) were constructed in both points, which are similar to the hole N 4 at the GO 'Borovoye' base point. In both points the electric power supply was provided by a battery. At present time, both points are put in a prolonged storage.

A remote points 'Zerenda' (ZRN), 'Chkalovo' (CHK) and 'Vostochnyi' (VST) are located correspondingly at the territories of Zerendinskii, Chkalovskii and Enbekshiderskii districts, belonging to the Kokchatavskaya province. Observations had been carried out in these points on a mobile digital stations PCS (ПЦС)[6]. Seismometers had been installed in pits at a depth of 1-1.5 meters or on surface, straight on the outcrop of bed rocks. The true altitudes of observation points ZRN, CHK and VST are, correspondingly, 350, 140 and 300 meters. A recording equipment was placed at a distance of 50- 300 meters in the KUNG (КУНГ) trailer, which on winters was heated by electric heaters. The main disadvantage of these stations is the interruptions during recording because of the frequent switching-offs of industrial power supply.

The remote point 'Karaganda' (KRG) is located in 3 km from Berezhnyaki village, near Temir-Tau city, at the territory of Karagandinskaya ionosphere station, which is belonging to the Ionosphere branch of the Kazakstan Academy of Science. This point was under operation during experiment KRG-OSB (КРГ-ОСБ). Seismometers were placed in a pit, at outcrops of bed rocks in 300 meters from the recording device, which was placed in a room in the laboratory building of the ionosphere station. The photographic recording was carried out by OSB-VI (ОСБ-VI) oscillograph.

2.2 An analogous seismic station E4 (Э4).

2.2.1 A description of the instrumentation.

The E4 (Э4) seismic station at the GO 'Borovoye' base point have worked from the 28 of September 1965 till the 16 of October 1972. In the instrumentation set the seismometers SKM-3 (СКМ-3), SKD (СКД), USF (УСФ) (the last - for a short period of time) and galvanometers GK-7 (ГК-7), MG-1 (МГ-1), GB-3 (ГБ-3), GB-6 (ГБ-6) have been used. A recording was carried out by detectors RS-2 (РС-2), with a scanning speed for SKM channels – 60 mm/min, and for SKD channels – 30 mm/min. Also, in the instrumentation set some standard devices had been used: a monitoring-distributor desk KRP (КРП), governor AUZ (АУЗ) to control the recording, an unit to receive signals of time correction RFU (РФУ) and a panel PRUOP (ПРУОП). At the beginning, the time marks were given from a marine minute chronometer MH-6 (МХ-6), but from November 1967, they were given from quartz -crystal clock PKCh-2 (ПКЧ-2). A power supply to the instrumentation was widely used on the standard seismic stations ESSN (ЕССН) of the USSR.

A radiosignal for the time calibration (6 pulses at the end of an hour), which is applied through RFU (PΦY) to the record, is consistent in an observation area with a global time with an error not more than 0.5 sec. The standard time signals for a referencing of quartz-crystal clock PKCh-2 (ΠKЧ-2) is consistent with a global time with an error not more than 0,01 sec. By testing, it was determined, that the time mark delay in KRB (KРБ) was less than 0.06 sec.

An amplification of the main channels (SKN (CKH) and SKD (CKД)) was, correspondingly, 10^5 and 10^3 , and the amplification of low-sensitive channels (KPCh (KΠЧ)) was ten times less. The relative amplitude-frequency characteristics of the channels are shown on fig 2.3. Some periods of time (because of the absence of the records and so forth) were duplicated with a photogalvanometrical recording of the SKM (CKM) channels from the KOD (КОД) system.

The seismograms from the E4 (Э4) seismic station are kept in the GO 'Borovoye' archives.

2.2.2 The KRG-OSB (KPT-OCБ) experiment.

The KRG-OSB (KPT-OCБ) experiment - is a conventional name of the temporary observations near the Berezniaki village of Karagandinskaya region, being carrying out from the 5 of October 1972 till the 9 of October 1973. The aim of this experiment was to determine an efficiency of the recording of volumetric waves in this point. The seismometrical channels consisted of the seismometers USF (YCΦ) and the galvanometers GB-4 (ГБ-4). The oscillograph OSB-VI (OCБ-VI), with a scanning speed 60 mm/min was used as a recorder (detector). The time marks were given from the marine minute chronometer MH-6 (MX-6). The time corrections for the chronometer were determined by the radiosignals.

In 1971, the observations of the level of a microseismic background in this area were carried out. The seismograms of the experiment KRG-OSB (KPT-OCБ) are kept in the GO 'Borovoye' archives.

2.3 The system of the digital recording KOD (КОД).

2.3.1 A description of the instrumentation.

The KOD system - is a digital seismic station. Observations by the stations of this type had been carried out at the GO 'Borovoye' base point and at the remote point 'Jukei'.

A block diagram of the KOD system is shown on fig. 2.4. The seismic-amplifier channel is consist of the seismometer SKM (CKM) (or USF (YCΦ)), photo-amplifiers F117 (Φ117) and a semiconductor amplifier KOD-I (КОД-I). A forming of the amplitude- frequency characteristics is determined by characteristics of the seismometer, photo-amplifiers and filters in KOD-I. Besides, there

are rejection (suppression) filters for each channel in KOD-I for frequencies 0.145 Hz and for 50 Hz. For each component there is a recording by two channels: main channel (h) and a channel with low sensitivity (approximately ten times less) (l). The maximal double amplitude at the KOD-I channel's output is 9-10 V. All units of the seismic amplifier channel were installed in the adit.

A commutator of the analogous voltage (KAN (KAH)) commutes 10 analogous input voltages sequentially to the input of the A/D converter. The A/D converter has 11 positions for the data code and 12 positions for the time code (codes are binary). The channel distributor (RK (PK)) distributes among 5 channels the values on the digital magnetic tape recorder LMR-ShA (JIMP-IIIa) with the following notation: 'high level' – h / l and 'low level' – l / l.

The time generator is a quartz-crystal clock PKCh-2 (ПКЧ-2). A fixation (referencing) of the PKCh-2 (ПКЧ-2) to the global time is made in an even hour. A determination of the PKCh-2 (ПКЧ-2) time errors with an accuracy of 0.01 sec can be carried out in every even minute by the standard time signals, transmitting by the GSVCh (ГСВЧ) of the USSR radiostations. As it was mentioned above, the standard time signals are consistent with the coordinated time with an error not more than 15 microsecond. The time binary code is formed in the A/D converter from 0.5 min up to 24 hours. There is a check of the time errors of the A/D converter in the system (when disagreement with the PKCh-2 (ПКЧ-2) time is more than 20 millisecond).

There is a calibrator in the system to make the on-line check of the capacity for work of the seismograph channel. It is checked by sending a unit impulse function voltage on a damper coil of the seismometer. The amplitude-frequency characteristics of the channels are determined by the generator method.

A checking visible recording is made by a recording pen, and a photo-galvanometric recording is made by an OSB-VI (ОСБ-VI) oscillograph.

Table 2.3

The settings of the channels of the KOD-BRV (КОД-БРВ) system, high level (h/l)

The time of the recording	Channel N1	Channel N 2	Channel N 3	Channel N 4
23.07.66 - 04.11.66	NSI	ZI	NSh	Zh
16.12.66 - 05.09.67	Zh	ZI	NSh	EWh
05.09.67 - 06.09.67	Zh	USF-Zh	NSh	EWh
06.09.67 - 13.09.67	Zh	USF-Zh	NSh	EWh
14.09.67 - 25.09.67	Zh	USF-Zh	NSh	EWh
26.09.67 - 28.09.67	Zh	USF-Zh	NSh	EWh
28.09.67 - 05.10.67	Zh	USF-Zh	NSh	EWh
05.10.67 - 12.10.67	Zh	USF-Zh	NSh	USF-Zh
12.10.67 - 01.11.67	Zh	USF-Zh	NSh	EWh
02.11.67 - 30.11.67	Zh	--	NSh	EWh
30.11.67 - 15.03.68	Zh	ZI	NSh	EWh
15.03.68 - 17.12.68	Zh	EDMB	NSh	EWh
18.12.68 - 27.05.69	Zh	--	NSh	EWh
28.05.69 - 24.09.69	Zh	ZI	NSh	EWh
24.09.69 - 29.09.69	Zh	ZI	NSh	EWh
29.09.69 - 13.11.73	Zh	ZI	NSh	EWh
	Zh			

The designations in the table:

-Z, NS, EW - the SKM (SKM) channel's components;

-EDMB - microbarograph;

Table 2.3 (continuation)

The settings of the channels of the KOD-BRV (КОД-БРВ) system, 'low level' (I/I)

18.05.67 - 20.08.67	Zh	ZI	NSI	EWI
20.08.67 - 21.08.67	USF-Zh	ZI	NSI	EWI
21.08.67 - 30.08.67	Zh	ZI	NSI	EWI
30.08.67 - 05.09.67	USF-Zh	ZI	NSI	EWI
05.09.67 - 25.09.67	ZI	USF-ZI	NSI	EWI
26.09.67 - 28.09.67	ZI	--	NSI	EWI
28.09.67 - 01.11.67	ZI	USF-ZI	NSI	EWI
02.11.67 - 29.11.67	ZI	GF-HF-EW	NSI	EWI
29.11.67 - 13.03.68	GF-HF-Z	GF-HF-EW	NSI	EWI
13.03.68 - 04.06.68	GF-LF-Z	ZI	NSI	EWI
04.06.68 - 07.10.68	--	ZI	NSI	EWI
07.10.68 - 14.05.69	ZI	Zh	NSI	EWI
14.05.69 - 27.05.69	ZI	--	NSI	EWI
28.05.69 - 24.09.69	ZI	Zh	NSI	EWI
24.09.69 - 29.09.69	ZI	Zh	NSI	EWI
29.09.69 - 13.11.73	ZI	Zh	NSI	EWI

Designations in the table:

-Z, NS, EW - the SKM (CKM) channel's components;

-EDMB - microbarograph;

-GF-HF - geo-electromagnetic field high-frequency channels;

-GF-LF - geo-electromagnetic field low-frequency channels.

2.3.2 A KOD-BRV (КОД-БРВ) system.

A KOD-BRV (КОД-БРВ) system -- is a station, working on a main base point of GO 'Borovoye'. A magnetic digital recording on it had been carried out from the 23 of July 1966 till the 12 of November 1973. During this period of time, the KOD system had recorded seismic events, as well as a micro-variations of an atmospheric pressure and the geo-electromagnetic field. In some cases the same channels had double recording on the 'high' and 'low' levels.

The amplitude -frequency characteristics of the SKM(CKM) and USF(YCΦ) channels are shown on fig.2.4. The non-linearity of the amplitude characteristics of the SKM(CKM) in most cases is more than 52% -- with a double amplitudes being lower than the maximal signal amplitude (2048 units). The results of the determination of the maximal signal amplitudes, corresponding to the non-linearity of 5-10%, are in accordance with the last statement. It is necessary to take this fact into account during processing the magnetic digital records (MCZ (MLI3)) of the KOD system, as well as the fact, that these determinations were carried out at a frequency of 1.5 Hz -- that corresponds to the maximum value of the amplitude-frequency characteristics curve. On the slopes of the amplitude-frequency characteristics curve the maximal amplitudes would be less. For example, at a frequency of 0.1 Hz the maximal double amplitude of the non-distorted signal is about 900-1000 units.

The maximal double amplitudes on the USF(YCΦ) channels output is 1200-1400 units at a frequency of 0.8 Hz. A level of the internal noise of the amplifier channels, in some cases, was more than 5 mV, that corresponds to the one code unit. The instability of the sensitivity of the seismic-amplifier channels with the time is up 10%, and at the first moment after the switching on it can reach up to 12-40%. This can be seen from the change of the amplitude of the calibration pulses of the decoded magnetic digital records. The signal interrelationship between the channels during all checks was not more than 12%.

The checking photo-recording of the KOD channels by the OSB-VI (ОСБ-VI) oscillograph had been made from time to time, and as a rule, during interruptions of the seismic station recordings (see table 2.3). The check visible recordings had been made for the on-line data processing, so these records are not remained.

2.3.3. The 'Jukei' experiment.

The 'Jukei' experiment -- is an observations at the remote point 'Jukei' (JK), that had been carried out from the 17 of September till the 20 of October, 1967 by the KOD seismic station. This sta-

tion is similar to the station at the GO 'Borovoye' base point. The USF(YCΦ) seismometers were used in the seismic amplifier channels, there was no check recordins, recording was made by the single LMP (JIMII) magnetic tape recorder. It is necessary to note, that the horizontal seismometers at the 'Jukei' point were oriented along a magnetical meridian and a parallel. A magnetical deviation at this place is equal to

$10.3^{\circ} \pm 0.5^{\circ}$ to the east (it was determined be a test).

The setting of the channels hadn't been changed during all the time of the experiment execution.

The channel N 1 -- Zh component;

The channel N 2 -- Zl component;

The channel N 3 -- NSh component;

The channel N 4 -- EWh component;

The amplitude frequency characteristics are shown on fig 2.5. The internal noise level of the amplifier channels was not more than 6 mV.

The magnetic tapes had been brought by a car to the GO 'Borovoye' base point every day during the experiment execution, where all the necessary parts of the records had been transcribed at the special viewing and transcribing (re-recording) device.

A collection of the documents on the KOD system, the instrumental books and the log books, as well as the magnetic digital records and the check seismograms are kept in the GO 'Borovoye' archives.

2.4 A digital recording station SCR-SS (CIIP-CC).

2.4.1 A description of an instrumentation.

The SCR-SS (CIIP-CC) station had worked at the GO 'Borovoye' from February 1973 till 1989, without interruptions, except short-time pauses for a re-tooling and for a service operations.

A generalized block diagram of the digital recording station is shown on fig. 2.6. The only difference between the SCR-SS (CIIP-CC) system and the shown block diagram is that the SCBM 'Planeta-3' (ЦИБМ 'Планета-3') had been used only for the recurrent determination of the AFC and AC of counting channels and to check a serviceability of the SCR (CIIP) system as a whole.

The SKM (CKM) and SKD (CKД) seismometers, previously being a part of a seismic station instrumentation, had been used in the SCR-SS (CIIP-CC) counting channels. An operating coils in these channels were changed in a favor of the more high-ohm coils, in order to increase a magnetoe-

lectrical constants. The magnitudes of the moment of inertia and a reduced length of the seismometers were re-computed because of a change in a coil's weight. The calibration block makes an on-line check of the capacity of the work of the counting channels, applying a unit impulse of a current of both polarities onto the seismometer's damper coil. The channel's commutator has a 10 channels with a various measuring frequencies for the short-period and for the long-period channels. The A/D converter has 11 positions, where a value of the least significant position is $4.970 \text{ mV} \pm 0.4\%$, and the non-linearity within the conversion scale is 1-2.5%. A conversion frequency is 166.6 readings (samples) per sec ($T = 6 \text{ msec}$), but it can be change to the following values: 500, 1000, 2000 and 4000 samples per sec.

The magnetic digital recording had been made by the LMR-VI (JIMP-VI) magnetic tape recorder. The time of the continuous recording was ~ 8 hours.

A recorder of a visible records (RVZ-2 (PB3-2)) had been used for a check recording.. The SCR-SS (CLIP-CC) system has two RVZ-2 (PB3-2): one – for the SKM channels with a scanning speed 60 mm/sec, and the other – for the SKD channels with a scanning speed 30 mm/sec. The RVZ-2 (PB3-2) has a means to change on-line an amplification of the chose channels. As a rule, the main recording of the SKM and SKD channels had been made by the RVZ-2 (PB3-2). A photogalvanometrical recording had been made by the GB-4 (ГБ-4) galvanometers, with a RS-2 (PC-2) recorders, with a scanning speed 60 mm/sec and 30 mm/sec for, correspondingly, the SKM and SKD channels. A recording of the main channels, as well as the low-sensitivity (KPCh (КПЧ)) channels had been carried out.

A time check block had ensured a referencing of records to a coordinated time scale UTC (SU) with an error not more than 0.005 sec (taking into account a time of a wave propagation from a transmitting radiostation).

The seismometers and the parametric amplifiers were located in the west chamber of the mine. A recording instrumentation (without the SCBM (СЦЕМ)) had been placed in a seismic station room from the 20 of July 1981 toll the 1 of August 1981, and after that it was moved to the equipment room N1 of the laboratory building N 1.

The magnetic digital records from the GO 'Borovoye' archives, are started, as a rule with a records of a micro-seismic noise, 3 minutes before a P-wave arrival. A setting of the SCR-SS (CLIP-CC) channels is given in the table 2.4. A generalized AFC curves of the counting channels are shown on figs. 2.7, 2.8. A photogalvanometrical recording had been made from the 27 of February 1973 till the 16 of July 1981, during a time before a SCR-SS (CLIP-CC) was moved to the laboratory build-

ing N 1. A checking visible records on the RVZ-2 (PB3-2) had been carried out from the 25 of February 1973.

The magnetic digital records, the photo- and the check records from the RVZ SCR-SS (PB3 CIIP-CC) are kept in the GO 'Borovoye' archives.

Table 2.4.

The settings of the SCR-SS (CIIP-CC) channels

SCR channels numbers	Time of recording			
	from 07.03.73 till 18.04.73	from 19.04.73 till 20.07.81	from 01.08.81 till 14.07.82	from 18.08.82 till 31.01.89
1	—	SKM-Zl	-	SKD-Zl
2	SKD-Zm	SKD-Zm	SKD-Zm	SKD-Zm
3	SKD-NSm	SKD-NSm	SKD-NSm	SKD-NSm
4	-	SKD-EWm	SKD-EWm	SKD-EWm
5	SKD-EWm	-	-	SKD-NSl
6	ACC	ACC	SKM-Zl	SKM-Zl
7	SKM-Zm	SKM-Zm	SKM-Zm	SKM-Zm
8	SKM-NSm	SKM-NSm	SKM-NSm	SKM-NSm
9	SKM-EWm	SKM-EWm	SKM-EWm	SKM-EWm
10	-	-	-	SKD-EWl

l-low-sensitive (KPCh) channel;

m-main channel.

2.5 The SCR-TSG (CIIP-TCT) digital recording station.

2.5.1 A description of the instrumentation..

The SCR-TSG (CIIP-TCT) station works from the 18 of July 1974. The only difference between the block diagram of the SCR-TSG (CIIP-TCT) station and the diagram, shown on fig 2.6 is the absence of the photogalvanometrical recording in the SCR-TSG (CIIP-TCT) station. The SCR-TSG (CIIP-TCT) station has a 24 counting channels to record seismic signals. All units of

the SCR-TSG (CIP-TCI) station are analogous to the units of the SCR-SS (CIP-CC) station, except the channel commutator and the LMR-VI (JIMP-VI) magnetic tape recorder. A value of the least significant position of the A/D converter is $4.89 \text{ mV} \pm 0.1\%$, the non-linearity within a conversion scale of the A/D converter is 1-2% (according to the 24 measurements, being carrying out from 1974 till 1983). A conversion frequency of the A/D converter is 500 Hz ($T = 2 \text{ msec}$). The LMR-VI (JIMP-VI) magnetic tape recorder has a tape transport speed of 50 mm/sec, giving a time of a continuous recording the 2 hours and 50 minutes.

The period of measurements (speed of scanning) for the channels 1-12 is 25 msec; and for the channels 12-24 – is 312 msec. The channels 1-12, as a rule, are used to record by the short-period channels (KS (KC), SBU (CBY), SD-1F (CД-1Φ)), and the channels 13-24 – to record by the long-period channels (DS (ДC), DSM (ДCM)).

Micro-variations of the atmospheric pressure ('acoustics') and the short-period variations of the geo-electromagnetic field ('EMPZ' ('ЭМПЗ')) have been recorded in a course of some experiments.

When working in the ASS (ACC) mode of the digital recording on the LMR-VI (JIMP-VI), the signals, selected by a seismic signal analyzer ASS (ACC), had been recorded during 4 or 6 minutes, starting a one minute before a found (picked) arrival. In the ACP (АЦП) mode, the recording on the LMR-VI (JIMP-VI) is carried out continuously, with subsequent transcribing of the needed time periods.

It is necessary to note, that there was a malfunction in a channel comutator (from the 24 of August 1982 till the 18 of January 1984): when in any two channels a double signal amplitude is more than ~1600 code units, and these signals are in the antiphase, then there would be distortions of the signals (an abrupt decreasing of the amplitudes) in both channels.

The SCR-TSG (CIP-TCI) station is used, as a rule, for experimental works to develop new counting channels and to refine its parameters,

2.5.2 Short-period channels.

The following short-period channels had been used in SCR-TSG (CIP-TCI) system: KS(KC), CBU-SV (CBY-CB), CD-1F (CД-1Φ), CVK-KSM (CBK-KCM) and M-KSM (M-KCM). The names of their seismometers are given in the names of the channels. The 'SVK' – means super high sensitive channel, M – means – modernized (updated) channel. The KS (KC) channels works from July 1974 till the present time. Their AFC are shown on fig 2.9. The channel Z-KS N 7 have been used to find the seismic signal arrivals on a SCVM (CIBM – seismic digital computer) 'Planeta-3'

by studying the signal's amplitude. For this task the software 'AP' (АП) (1976—1980) and 'BTR' (БТР) (1980—1985) had been used. The sources codes of these utilities, along with the results of their work are kept in the archives. The non-linearity of the amplitude characteristics is, as a rule, not more than 5%, except the period 1974-1975, when it reached 10% by Z component. The internal noises of amplifying channels are not more than 1 unit of the least significant position (register) of the A/D converter. The interrelationship by signal between channels is not more than 1%. The check recording had been made on RVZ-2 (PB3-2) pen recorder with a speed of 60 mm/sec.

The SBU-V (СВУ-В) channel had worked from December 1977 till January 1985. The SBU-V (СВУ-В) seismometer has one coil, so its calibration its calibration was made according to the technique, described in [14]. The channel's AFC is shown on fig 2.10. The non-linearity of amplitude characteristics is not more than 2%, the internal noise of the amplifying channel is equal to 1-2 units of the least significant position of the A/D converter.

The SD-1F (СД-1Ф) channel had worked from December 1977 till December 1985. The channel's AFC are shown on fig 2.11. The non-linearity of amplitude characteristics was not more than 3%, the internal noise of the amplifying channel is equal to one unit of the least significant position of the A/D converter.

The SVK-SKM (СВК-СКМ) channels are the most sensitive channels at the GO 'Borovoye'. At the beginning, from November 1981 till September 1984 one channel only (N 10) had worked. After that, from January 1985, the three-component system started to work. The recording is made for each component by two channels: main channel and low-sensitive channel (KPCh (КИЧ)). The sensitivity of the KPCh channel is 100 times less the sensitivity of the main channel. The SVK-SKM (СВК-СКМ) channel's AFCs are shown on fig 2.11. The non-linearity of the AC is not more than 2%. The internal noise of the amplifying channels is less than one unit of the least significant position of the A/D converter ($\sim 0.7-3.0$ mV). The interrelationship by signal between channels is $<1\%$.

The M-KSVM (М-КСВМ) modernized channel have worked from December 1983 till December 1985. The vertical (Z) component only was recorded. It was recorded on two levels: on the main channel and on the low sensitive (KPCh) channels. The sensitivity of the KPCh channels is 100 times less the sensitivity of the main channel. The channel's AFC are shown on fig 2.13. The non-linearity of the amplitude characteristics is not more than 0.8%. The internal noise of the amplifying channels is much less than the one unit of the least significant position of the A/D converter ($\sim 0.5-0.9$ mV).

2.5.3. The long-period channels.

The following channels work in the SCR-TSG (CLIP-TCI) system: DS (ДC), M-DS (М-ДC), DSM (ДСМ) and SVK-DSM (CBK-ДСМ).

The DC (ДC) channels have worked from July 1974 till December 1985. From November 1983 till February 1985 it was carried out an experimental checking of the M-DC (М-ДC) modernized channel on the EW (B3) component on the base of the DC (ДC) seismometer. The AFC curves of the DC (ДC) channels are shown on fig 2.14. The non-linearity of the amplitude characteristics, was, as a rule, not more than 5%, except 1974-1975 years, when it was about ~10%. The internal noises of the amplifying channels were not more the one unit of the least significant position of the A/D converter. The interrelationship by signal between channels was $\ll 1\%$.

The M-DC (М-ДC) channel have worked on the EW component from November 1983 till February 1985. The recording was made by two channels: the main channel (N 14) and the low sensitive channel (KPCh N13). The low sensitive channel has a sensitivity 100 times less the sensitivity of the main channel. The AFC curves of the M-DC (М-ДC) channel are shown on fig 2.15. The non-linearity of the amplitude characteristic is not more then 0.5%. The internal noises of the amplifying channels – are significantly less than one unit of the least significant position of the A/D converter (~0.6 mV).

The DSM (ДСМ) channels have worked from November 1975 till August 1982. The DSM-Z (ДСМ-Z) seismometer was removed in November 1982 for an experimental testing in a complete with the super-high sensitive channel DCM (SVK-DSM (CBK-ДСМ)). The AFC curves of the DSM channels are shown on fig 2.16. The SVK-DSM channels are the most sensitive channels among the all long-period channels. From November 1981 till January 1985 the experimental testing had been carried out only on the one vertical component (channel N 22). From January 1985 the three-component set SVD-DSM (CBД-ДСМ) started to work. The recording for each component have been made on two levels: the main level and the low sensitive level, with a sensitivity 100 times less. The non-linearity of the amplitude characteristic curves was not more than 2.5 %. The internal noises of the amplifying channel were significantly less the one unit of the least significant position of the A/D converter (~0.3-1 mV). The interrelationship by signal between channels was $\ll 1\%$.

2.6. The PCS (ПЦС) station.

The PCS (ПЦС) station – is a mobile digital station. It was used to record seismic events of the temporary remote points 'Zerenda', 'Vostochnyi', 'Chkalovo'. The station have worked from July 1973 till November 1978.

The block diagram of the PCS (ПЦ) station is similar to that of the SCR (СЦ) station, the difference is that the PCS system had no SCVM (СЦВМ) (seismic digital computer) , photogalvanometrical and checking visible recording.

The F4880 (Ф4880) converter, which has 11 positions of the binary code with a sign and a periodicity of measurement $T=8$ msec, was used as a A/D converter in the PCS system. The sensitivity of the A/D

Table 2.5.

The PCS (ПЦ) channels measurement intervals.

Number of channels	channels or-deal number	measurement intervals, millisec	measurement frequency, readings/sec	the maximal error of time recording, sec
3	1, 2, 3	32	31.2	-0.032
7	1, 4, 5, 6, 7, 8, 9	64	15.6	-0.064
12	1, 2, 3, 4, 5, 6, 7, 8, 9	88	11.4	-0.088
	10, 11, 12	264	3.8	

converter was 0.5 mV/code unit $\pm 1\%$, with a conversion non-linearity not more than 2.7%. It is necessary to note, that later all of the PCS (ПЦ) magnetic records were transcribed into 11-position codes without a sign, in order to get the same code numbers as in the SCR (СЦ) system [6]. Because of this, the recording sensitivity had decreased in two times and become 1 mV/code unit.

The time service in the PCS has the same parameters, as in the SCR: a referencing of records to a coordinated time scale UTC (SU) with an error not more than 0.005 sec. The only exception was the PCS station, which have worked in the 'Zerenda' point, where the global time referencing was made with an error of 0.1 sec.

The short-period three-component channels, created on a base of the KSM (KCM) seismometers were used in the PCS system. The setting of the all channels during all the time of the recording in all points, was the same and wasn't changed.

The channel N 1 – KSM-Z;

The channel N 2 – KSM-NS;

The channel N 3—KSM-EW.

There was a three-channel mode of operations on the remote points 'Zerenda' and 'Vostochnoyi'. On the remote point 'Chkalovo', the mode of the operation of the PCS was changeable: three-, seven-, and twelve- channels (see table 2.6).

The AFCs curves of all the counting channels are identical, with an error not more than 10%. The AFCs are shown on fig 2.17. The amplitude characteristics of the counting channels up to the maximal signal amplitude within the A/D converter's conversion scale., at a frequency of 1.5 Hz are linear with an accuracy of 5%. The amplitude of the internal noises of the amplifying channels is not more than the one unit of the least significant position..

All information about the PCS system, as well as the PCS magnetic digital records are kept in the GO 'Borovoye' archives.

Table 2.6.

The PCS (ПЦС) operation modes

ZERENDA		VOSTOCHNYI		CHKALOVO	
date	mode	date	mode	date	mode
21.09.76	the start of the recording three-channel	27.07.76	the start of the recording, three-channel. The NS and EW channels polarity is reverse	11.09.76	The start of the recording, three-channel
		13.08.76	The NS and EW channels polarity is normal		
24 - 30.09.76	channel sensitivity lowering, 1:10	27.09 - 01.10.76	channel sensitivity lower- ing, 1:6.5	25.09 - 06.10.76	channel sensitivity lowering, 1:6.5
				07 - 11.12.76	the moving of the PCS in 250 meters to the north
				12 - 18.01.77	seven-channels
				18.01.77	twelve-channels
				08.04.78	three-channels
27.06.78	The end of recording	28.10.78	The end of the recording	20.07.78	The end of the recording

2.7 The seismic stations of the IRIS consortium of the Columbia University of the USA.

2.7.1. The IRIS-IDA seismic station.

The broadband digital seismic station IRIS-IDA was installed in the GO 'Borovoye' in July 1994, in accordance with the international agreement between the NNC RK and the IRIS consortium. The station set has three broadband seismometers STS-VBB Streckeisen and three short-period seismometers GS-13. The recording of the data is carried out onto a magnetic tape, and also in the conveyer mode onto hard drive of the SPARC PC station. The hard drive capacity allows the on-line access to the data for the last 9 days. Data are copied from the DAT-tape onto the tape of the same type and are keeping in the observatory in archives. The original records are sent to the USA every week.

The components of the IDA/IRIS seismic station.

1	The broadband seismometers Streckeisen (STS-VBB)	3
2	The short-period seismometers GS-13	3
3	The DAS block (RT 97-08)	1
4	The ARS block (RT 97-11)	1
5	OMEGA OM-DC external time clock	1
6	The HP3507A digital magnetic tape recorder	1
7	'WYST' console	1
8	The IGPP power supply system	1
9	The SPARC PC station	1

2.7.2 The 'PASSCAL' seismic station.

The four 'PASSCAL' seismic stations were installed on the large-base seismic array BSG-BRVK: Chkaloco, Zerenda, Vostochnoye and Borovoye. Three stations were placed in mines of the outlying points, and one station was installed in the mine of the GO 'Borovoye' base point.

All stations are equipped with the DAS, REFTEK data acquisition systems, with the 16-bite or 24-bites A/D converters. The stations have hard drives, with the 1 GByte capacities

each, that allows to store a data during 7 weeks, with the sampling rate of 40 Hz. The stations have uninterrupted power supply systems.

The data, obtained from the stations every week, is copied on the SPARC station and is sent to the USA.

The 'PASSCAL' seismic station, installed in the GO 'Borovoye', has the following components:

1	The 'PASSCAL' seismic stations	4
2	The SPARC PC station	1

The components of the PASSCAL seismic station are:

1	The STS-1 or CMG-3ESP seismometers	3
2	The DAS block (RT72A-04)	1
3	The ARS power supply unit (RT72A-04)	1
4	Hard drive memory (RT72A-05)	1
5	The external time clock	1

The AFC and PFC curves of the CMG-3 seismometer are shown on fig 2.18. The examples of the seismic signal records, made by the IRIS-IDA and PASSCAL stations are shown on figs 2.19, 2.20, 2.21, 2.22.

2.8 The seismic arrays in the GO 'Borovoye'.

The Kokchetav anticlinorium in the northern Kazakhstan has very high (good) efficiency of a recording of the seismic P-waves, arriving from the many parts of the globe [16]. The seismic observations by the arrays: 'Krest' (cross), 'Treugolnik' (triangle), 'Ojerelie' (necklace) have been made on the area of the Kokchetav anticlinorium from 1975. The arrays 'Treugolnik' and 'Ojerelie' were a part of the general system, named 'large-base array (BSG (BCI))'. The data from all of the counting channels of all three arrays were sending continuously to the central point by communication lines, where the hypocentres of events (geographic coordinates, time of the origin, depth, magnitude) were computed on the computer systems in the real-time mode by special programs. Also, it was made an identification of the event's source (explosion—earthquake). The digital seismograms were archived for a prolonged storage and for

and additional investigations. At present time, the modernization of the system is made, because of an adoption of the new recording equipment and methods of the data processing.

2.8.1 The 'Krest' (cross) array.

The 'Krest' array (SGK (CTK)) was put into operation in October 1975. The 21 seismometers are arranged into two profiles 'A' and 'B' that are perpendicular to each other, with a common center in the point 6AB (see fig 2.23). The distance between to adjacent points on each profile is about 2.2 km. A short-period vertical seismometer SBU-V (CBY-B) was installed in each point. Later on they were replaced by the K-213-CM-1 seismometers. A sensors were placed in holes, at a depths, ranging from 30 to 200 meters, depending on the level of the monolithic granites bedding. The data from every sensor was sent in an analogue form to the center of the SGK (CTK) where it was amplified, and after that it was sent to the central point (CP BSG (ЦП БСТ)) where it was transcribed into the digital code to process on the computing system.

The location of the SGK (CTK) sensors is listed in table 2.7. The SGK (CTK) points are located in different geological situations (structures), several faults (fractures) are passing through the profiles, and the most powerful one is located between the points 8A and 9A.

The fragment of the seismic records from several points of the SGK (CTK) of the underground nuclear explosion 'TARKO' (Nevada test site, USA) is shown on fig 2.24.

Table 2.7.

The coordinates of the 'Krest' seismic array (GO 'Borovoye')

SENSOR	LATITUDE, °, ',"	LONGITUDE, °, ',"	ELEVATION (km)	THE HOLE DEPTH (m)
1A	53 08 56.6	70 22 48.0	0.302	40
2A	53 07 54.3	70 23 49.2	0.313	40
3A	53 06 51.6	70 24 50.4	0.347	50
4A	53 05 47.9	70 25 50.4	0.345	50
5A	53 04 46.1	70 26 52.2	0.370	47
7A	53 02 40.0	70 28 53.6	0.385	77
8A	53 01 36.8	70 29 50.8	0.440	192
9A	53 00 32.8	70 30 54.9	0.450	200
10A	52 59 30.2	70 31 56.2	0.387	40
11A	52 58 28.8	70 32 53.0	0.412	35
1B	53 00 38.9	70 19 19.3	0.379	29
2B	53 01 18.4	70 20 58.5	0.363	30
3B	53 01 52.9	70 22 40.9	0.398	33
4B	53 02 30.2	70 24 26.7	0.485	64
5B	53 03 06.4	70 26 09.1	0.368	105
7B	53 04 19.2	70 29 38.4	0.465	29
8B	53 04 56.4	70 31 22.5	0.461	70
9B	53 05 32.5	70 33 07.1	0.355	36
10B	53 06 08.7	70 34 52.0	0.338	47
11B	53 06 50.4	70 36 50.0	0.322	30
6AB	53 03 43.4	70 27 53.6	0.390	76

2.8.2 The large-base array.

The large-base array (BSG (БСГ)) consists of four points: the central point (CP (ЦП)) in the Borovoye village, and three outlying points in Zerenda village (PP1), 'Vostochnyi' (PP2), 'Chkalovo' (PP3) of the Kokchetavskaya region.

The 'Treugolnik' (triangle) array had two modifications. From September 1976 till 1978 observations had been made on the temporary remote points (VVP (ВВП)) on the PCS (ПЦС) stations. From 1979 the recording was made on the outlying (peripheral) points (PP). (see fig 2.25). As it is seen, the PP1 and PP2 points have a small displacement in relation to the VVP points. The outlying points are equipped with three-component short-period sensors KSM (КСМ) and a long-period sensors DS (ДС), that are placed in chambers of the instrument structure's mine. The threshold sensitivity of the KSM (КСМ) channels is 0.13 nm for a frequency range 0.66—8.7 Hz. (at a half-level from the maximal sensitivity), and the threshold sensitivity of the DS (ДС) channels is 7.8 nm at a frequency range 0.04—0.61 Hz.

The 'Ojerelie' (necklace) sub-arrays, consisting from six NUP ((НУП) unattended remote point) each started to work near each PP from September 1978. The vertical seismometers SBU-V (СВУ-В) is installed into the mine of each NUP, the data is sent by cable to the instrumentation structure. The threshold sensitivity of the SBU-V (СВУ-В) channels is 0.3 nm, in a frequency range 0.73-3.5 Hz (at the 0.5 level).

The data from all channels of all PP of the BSG were sent continuously to the central point by radio-relay communication lines in the form of frequency-modulated signals in the audible band. The referencing of all seismic data to the standard time signals was made in the central point.

The diagram of the PP structures location are given on figs 2.26, 2.27, 2.28., their geographic coordinates are given in tables 2.8, 2.9, 2.10. The amplitude-frequency characteristics of the BSG channels are shown on figs 2.29, 2.30. The seismograms of the underground nuclear explosions 'KASH' and 'TAFI' in Nevada, recorded by the KSM and SBU-V channels of the BSG are shown on fig 2.31.

The outlying point 'Zerenda' (PP-I)

Table 2.8

№ №	The name of the structure	Geodetic B(latitude)	coordinates L(longitude)	Elevation H(M)
1	The central structure (top)	52°57'01.8"	69°00'20.2"	400.5
2	The central stricture (bottom) left chamber	52°57'02.1"	69°00'20.2"	384.0
3	The central structure (bottom) right chamber	52°57'02.1"	69°00'20.3"	384.0
4	Structure 4	52°58'13.6"	69°01'56.3"	382.2
5	Structure 5	52°56'46.1"	69°02'54.6"	407.1
6	Structure 6	52°55'37.7"	69°02'01.5"	405.4
7	Structure 7	52°55'45.7"	68°58'37.9"	388.0
8	Structure 8	52°57'16.5"	68°57'47.8"	364.5
9	Structure 9	52°58'37.6"	69°00'09.6"	368.2

The outlying point 'Vostochnyi' (III-2)

Table 2.9

№ №	The name of the structure	Geodetic B(latitude)	coordinates L(longitude)	Elevation H(M)
1	The central structure (top)	52°43'22.9"	70°58'49.7"	325.2
2	The central structure(bottom) left chamber	52°43'23.1"	70°58'49.5"	297.2
3	The central structure(bottom) right chamber	52°43'23.0"	70°58'49.9"	297.2
4	Structure 6	52°44'51.9"	70°57'53.7"	327.4
5	Structure 5	52°44'36.5"	71°00'15.2"	316.1
6	Structure 4	52°46'06.8"	70°59'26.2"	321.2
7	Structure 9	52°46'10.6"	70°57'03.9"	329.0
8	Structure 8	52°45'08.6"	70°55'15.8"	344.8
9	Structure 7	52°43'39.4"	70°56'13.1"	328.4

Table 2.10

The outlying point 'Chkalovo' (PP-3)

№ №	The name of the structure	Geodetic B(latitude)	coordinates L(longitude)	Elevation H(M)
1	The central structure (top)	53°40'31.8"	70°36'58.3"	140.0
2	The central structure(bottom) left chamber	53°40'32.1"	70°36'58.2"	123.5
3	The central structure(bottom) right chamber	53°40'32.1"	70°36'58.4"	123.5
4	Structure 4	53°41'42.7"	70°38'35.2"	131.0
5	Structure 5	53°40'17.7"	70°39'33.2"	136.7
6	Structure 6	53°39'03.3"	70°37'56.8"	148.2
7	Structure 7	53°39'14.2"	70°35'12.9"	147.0
8	Structure 8	53°40'46.6"	70°34'23.1"	140.0
9	Structure 9	53°41'50.9"	70°36'00.6"	132.5

2.9. The magnetic digital records archiving.

2.9.1. The devices for a viewing and a transcribing of the magnetic digital records

The instrumentation for a pre-view and for a transcribing are intended for a transcription of digital data from one magnetic tape onto another, for their viewing, and to obtain photographic or visible records in analogous form.

There are two types of the devices for viewing and transcription in the GO 'Borovoye': UP(VII) and UPZ (VII3). Basically, they are identical (UV (VB)). The digital data can be transcribed from one device onto another. The decoder chooses the needed channel number, minute and two-second time marks and gives the current time (hour, minute) on the time display. The data from the selected channel is converted into analogous form by 11-position D/A converter, after that it can be viewed on the cathode-ray oscillograph; or it can be recorded whether on the mirror-galvanometer oscillograph OMC or on the pen-recorder H338. The galvanometer's matching device provides the change of the sensitivity of the OMC records. The change of a sensitivity of the visible

records is made in the amplifier, which is a part of the H338 pen-recorder set. The UV(YB) magnetic tape recorders have two tape advance speeds: 250 and 500 mm/sec. Usually, it is used the speed of 250 mm/sec.

The magnetoelectrical galvanometers GB-4 (ГБ-4) are used in the OMC oscillograph to write a signal with a speed $f_0=120$ Hz and to write a time marks with a $f_0=300$ Hz. Taking into account, that the transformation ratio for a speed of magnetic records playback can reach up to 16 times, and the upper cut-off frequency of the recording signal is not more than 3-5 Hz, so the use of the galvanometers with $f_0=120$ Hz will lead to the absence of the frequency dependencies of photo-optical records. When the bandwidth of the counting channel is extended in a favor of high frequencies, it is necessary whether to take into account the galvanometer's AFC, or to change it by the more-high-frequency galvanometer.

The minute and two-second time marks, written directly onto magnetic tape, are sent to the OMC photo-recording. Besides, it is possible to receive the time marks which are equal to the $T*100$, that is, 0.6 sec for the KOD and SCR-SS stations, 0.2 sec for a SCR-TSG station, and 0.8 sec for the PCS station. The recording of these marks is started with every even odd second for the SCR and PCS stations, and with every S minute for the KOD station. All time marks are written on the upper and low edges of the photographic film for the better convenience of the processing.. In addition to these time marks, the referencing time mark, by which the current time marks are fixed, is written onto photographic film. The 'referencing' time mark is defined by an operator, and it is given in hours and in minutes.

2.9.2 The archiving of magnetic digital records.

The archiving of the magnetic digital records is carried out in two stages.

At the first stage the time intervals with earthquakes, that were selected by an operator from whether the continuos or from the photo-optical seismograms, are written into an intermediate archives. The re-records, as a rule, start in 3 minutes before the selected earthquake arrival, and finish 3-4 minutes after an arrival. Sometimes, re-record is made till the end of all seismic waves of the earthquake, including surface waves. The recording in the MZ-2 (M3-2) mode (SCR-SS and SCR-TSG) provides an automatic re-writing of the data, selected by the seismic signal analyzer (ASS) during 4 or 6 minutes, beginning a 1 minute before an arrival. So, the first stage services to select seismic signal records, mostly the short-period ones.

The association of all the earthquakes included into the intermediate archives is necessary to make before the second stage begins. The association is made by 'Regional catalogue of earthquakes', which is published by the International Seismological Center. The association is made by one feature only: the conformity between the earthquake arrival time in the observation point and the time of the event's origin, with a correction to a distance from the event's epicenter. Of course, this association can lead to errors, because of an accidental coincidence of epicenter parameters with other earthquake. It is necessary to take this fact into account, when using the magnetic digital records catalogue of associated earthquakes, created in the GO 'Borovoye'. The information about each earthquake in the GO 'Borovoye' catalogue is written on a special card, with the following information about the event: coordinates, the origin time, magnitude, depth, the ordinal number of the magnetic tape with event's records, frame information (the times of the beginning and of the end of the record). This information corresponds to the digital station's records, being kept in the intermediate archives.

During the second stage of the archiving, all associated earthquakes are written into the final magnetic digital records archives. All not-associated earthquakes are erased. Since the 'Regional catalogue of earthquakes' comes in 2-2.5 years only, so during this time all recorded earthquakes are kept in the intermediate archives. At present time, the catalogue of the magnetic digital records has the data about associated earthquakes from August 1966 till June 1996. The final magnetic digital records archives have the data till the end of 1985. During the second stage of the archiving, as a rule, it is erased about 30-40% of records from the total number of records. This occurs, since the earthquakes with a magnitude of 4 or more only, are included into regional catalogue.

3. Geophysical observatory " Kurchatov ".

3.1. Operating conditions.

The central geophysical observatory " Kurchatov " is situated in the north - eastern part of Republic of Kazakhstan in the distance of 145 km from Semipalatinsk city.

Kurchatov city is situated in the distance of 3 km from observatory. Observatory consists from 2 sites, and second technical site is situated in the distance of 2 km from the central site. The lay of the ground consists mainly from valleys. Absolute altitudes equal to 160 - 200 m. The region is open, without trees and bushes - it is the left bank of Irtish river.

The climate is straight continental, droughty. The moderate temperature per year is 6 C. The winter is long, cold, with not deep snow cover. Absolute minimum of temperature is 35 C below zero. The depth of season freezing of soil equal to 2.5 m. Wind velocity in the autumn - winter time amount to 25 - 30 m/s. The summer is hot, droughty. Absolute maximum of temperature is 46 C above zero. The level of annual precipitation equal to 250 mm. In the winter time under the territory the northern, north-western winds prevail, in the summer time - western and north-western winds.

The technical building of central site was built in 1960 y., the technical building of second site was built in 1964 y.

Geophysical observatory " Kurchatov " is equipped with apparatus, that allow to determine the time, coordinates, intensity of seismic events of the Earth with high accuracy, and also allow to produce the control for carrying out of nuclear explosions : ground, underground, air, and space nuclear explosions on the foreign testing ground, and to make the observe for radiation situation. The main method of registration of seismic events is geophysical method.

Communication center of observatory has two-channel communication system upon П303 and П327, two telegraph channels and two telephone channels upon the system " PARUS " with communication center " Yunost " and center of process information of MD RF service in Dubna. One of the phone channel supports the connect with Kurchatov intertown station.

Power supply of observatory is provided from the state network " Altayenergo ". There is full redundancy of all power supply of technical equipment of sites number 1 and number 2 from the storage battery room. Heating of sites is independent, water-supply is accessible from the town.

Characteristics of seismic noise at the geophysical observatory " Kurchatov " were researched upon the records of the broadband STS-2 seismometer with analog-to-digital

[A/D] converter equal to 24 bit, that was produced during 1 - 2 October 1994 year. Records of seismic noise for 3 hours from 08 till 11, from 13 till 16 and from 03 till 06 of local time were analyzed. Dependence of spectral density of seismic noise from frequency for the range of frequencies from 0.001 till 10 Hz is shown on fig. 3.1. Spectral component for the frequencies equal to the values below 0.1 Hz was obtained in the morning hours (08-11), while for the frequencies equal to 0.1 - 10 Hz spectrum was obtained in the night hours (03-06). The model curve of seismic noise is shown for comparison, from where we can see, that in the range of frequencies from 0.01 till 1 Hz the seismic noise within the limit of 10 dB coincides with model curve, and even in the range 1 - 5 Hz the level of seismic noise is lower than - (minus) 140 dB. From the industrial noise, that influence on the work of apparatus of GO " Kurchatov " is necessary to note the railway and the highway, that goes in almost straight north-south direction and cross the lines of sensors of seismic array "Cross " near HYII NN 8 and 16 (fig. 3.2). The noise, that is generated by railway trains, are situated in the range of frequency equal to 4 - 8 Hz. The traffic at the railway and highway is rare (4 - 5 trains per day).

3.2. The Seismic Array (SG) " Cross ".

The seismic array (SG) " Cross " consists from two orthogonal arms, every from which include 11 hole seismic sensors K-213-C (analog of seismometers WWSSN SP in the range of frequencies 0.5 - 2.5 Hz). The distance between the sensors in one arm equal to 2.25 km, total aperture length - 22.5 km. Orientation of " Cross " was chosen so, that we can increase maximumly the seismic signals from weak underground nuclear explosions, that are produced at the polygon in Nevada, back azimuth for which equal to 11.8 and epicentral distance - 91.5 (for the Lobnor test site, China, the back azimuth equal to 139 and epicentral distance - 1270 km). The scheme of distribution of sensors of SG is shown on fig. 3.2. Geographical coordinates of the holes are shown in table 3.1. All sensors are connected by cable lines of communication, that have a total length 120 km with central box at the remote point, where the technical building with the apparatus of sensor supply is situated. By the cable lines of communication the information is received by station of data processing, that is situated at the technical site N 2. In every hole on the different depths short-period seismic sensors with the period of natural oscillations equal to 2 sec are installed.

The coefficient of transformation of sensors equal to 75 000 V/m @ 2 s, dynamic range = 80 dB @ 2 s. Irregularity of amplitude - frequency characteristic in the range of frequencies 0.5 - 5 Hz doesn't exceed 3 dB, electromagnetic constant of calibration coil $G_k = (115 \ 25)$

H/A, the mass of active part of converter (0.25 0.025) kg. Output electric resistance of manufactured article not more 3 kOm. Electric supply of manufactured article is carried out by direct current with voltage from 11.4 to 25.2 V. Power consumption, when the voltage of supply is 12 V not more 0.3 W A. Till 1973 year so called " old system " worked.

Characteristics of it were not kept. The seismic array was reconstructed in 1986 - 1992 yy. Now working sensors K-213-C were installed. The signals of hole seismometers were filtrated by analogue high- and low-frequency filters with frequencies of section 0.5 and 2.5 Hz. Analogue signals from sensors were digitized by 16-bit analog-to-digital converter with frequency 100 readings/sec. Determine of seismic signals and localization of epicenters was carried out by computer CM-5300 (analog PDP-11). Localization of events and region was carried out by globe divided on 120 regions. All previous digital records were rewritten on this apparatus. Old amplitude-frequency characteristics of channels of SG are shown on fig. 3.3.

In October of 1994 year on the central point of collection of information on the second technical site 16-bit analog-to-digital converter [A/D] on the base of IBM/PC was installed. Analogue signals were digitized with velocity of 20 readings per second and were recorded continuously at the hard disk with volume equal to 4 Gb, and then were copied on the DAT cassettes for archive. In January of 1995 year the high frequency filters were deleted and the band was increased from 2 to 5 Hz. Velocity of reading was increased from 20 to 40 readings per second for increasing of resolution of high frequency regional signals. Amplitude-frequency and phase-frequency characteristics of system " sensor + amplifier " are shown on fig. 3.4. Accuracy conjunction to the time is carried out by the clocks of GPS system with resolution 2 msec. Data processing is carried out on the SUN 5 computer with using of JSPC (Joint Seismic Program Center) software.

Before the 1994 year SG submitted to Ministry of Defense of USSR and Ministry of Defense of RF. Unfortunately, during the transference of SG to IGR NNC RK almost all the documentation about the work of SG was withdrawn. All digital magnetic records of the period from 1973 till 1994 yy. were removed during the withdrawal of Russian troops to the Dubna city. In present the conversation about there restitution is carried out.

The archive of records of seismograms of system SG " Cross " from 1992 year on the paper mediums is took a place on the geophysical observatory " Kurchatov ". From the archive all the records of test nuclear explosions were withdrawn. The albums with the copies of seismograms of nuclear explosions since 1972 year are took a place. We have the complete archive on the DAT-cassettes since 1994 year.

Table 3.1

Geographical coordinates of holes SG " Cross ", GO " Kurchatov ".

SENSOR	LATITUDE, °	LONGITUDE, °	ELEVATION, km
CH01	50.7211	78.5625	0.2400
CH02	50.7017	78.5564	0.2400
CH03	50.6806	78.5475	0.2400
CH04	50.6622	78.5433	0.2400
CH05	50.6425	78.5367	0.2400
CH06	50.6056	78.5231	0.2400
CH07	50.5825	78.5169	0.2400
CH08	50.5631	78.5106	0.2400
CH09	50.5428	78.5047	0.2400
CH10	50.5239	78.4978	0.2400
CH11	50.6022	78.6861	0.2400
CH12	50.6058	78.6547	0.2400
CH13	50.6100	78.6247	0.2400
CH14	50.6147	78.5931	0.2400
CH15	50.6181	78.5617	0.2400
CH16	50.6272	78.4992	0.2400
CH17	50.6331	78.4681	0.2400
CH18	50.6347	78.4386	0.2400
CH19	50.6394	78.4056	0.2400
CH20	50.6439	78.3747	0.2400
CH21	50.6222	78.5311	0.2400

3.3. ASS " Parus ".

Automatical system of station (ASS) " Parus " had put into operation in 1985 year. System consists from the hole block and the unit of mating. Hole block consists from measure unit (three sensors kind of SDS-1, orientated upon the axis U, V, W) and data processing unit. Measure unit takes earth tremor over the range of frequencies 0.02 - 10 Hz by three channels U, V, W. Axis of channels are mutually-orthogonal and turned upon the axes on 120 relatively directions E - W, N - S and Z. Data processing unit makes analog-to-digital conversion (16-bit ADC), forms second data blocks and signal of synchronization and send it into unit of making. Band-pass filtration is carried out for every channel, transformation is carried out in three ranges:

Longperiod (LP) - 0.02 - 0.05 Hz

Middlperiod (MP) - 0.03 - 1.3 Hz

Shortperiod (SP) - 1.0 - 10.0 Hz

Frequency of digitization upon the ranges:

SP - 40 readings/sec

MP - 5 readings/sec

LP - 1 reading/sec

Hole block is situated in the hole with diameter equal to 300 mm on the distance of 150 meters to the south from the technical site N 2.

Unit of mating is carrying out the receipt of information, keeping, transformation and transmission of it to the center of processing of Service of Seismic Control of Ministry of Defense of RF, in accordance with agreement between Republic of Kazakhstan and Russia. At present, there is no data processing on this station. Amplitude-frequency characteristic of channels of ASS " Parus " is shown on fig. 3.5. Station works 24 hours a day.

3.4. Channel of registration N 10.

Channel of registration N 10 consists from stationary seismostation K-215-C and pen-recorder H 3031-6 with the chart speed equal to 1.2 sm/min. The sensor registrate

the vertical component of seismic signals. Channel is working in IGR since 1994 year. Recording is carried out 24 hours a day. Channel N 10 is longperiod. Archive records take a place in GO " Kurchatov ".

3.5. Channels of registration NN 11, 14.

Channels are working since 1962 year. The channels are stocked with geophones CBK-3M, blocks K-207-6 and K-210-C1, including filters and amplifiers and are took out to the pen- recorder H 3031-6 with the velocity of squandering 60 mm/min. The channel N 11 is shortperiod, channel N 14 is broadband. The channels registrate the vertical components of seismic signals. Channels work in all day time regime. Archival records of channels on the paper mediums take a place in the archive of GO " Kurchatov " since 1994 year (complete archive).

3.6. Channels of registration NN 24, 25.

Channels of registration NN 24, 25 consists from vertical sensors KCB-M-1 (channel N 24) and CBK-Д (channel N 25), galvanometer ГK-7, collimator K-8, registrir PC-2MK and control block ИYCC. The sensor KCB-M-1 is shortperiod vertical, CBK-Д is longperiod, vertical. Recording is photographic optical, 24 hours a day. Recording speed is equal to 1 mm/sec. Channel N 24 is working since 09.03.62 year, channel N 25 - since 05.03.70 year. Recording on the channel N 24 is carrying out in 5 regimes, on the channel N 25 - in one regime. Equipment of channel N 25 - analog of seismograph CKД that is wellknown at the seismic stations of former USSR. The archive records take a place since 1994 year.

Block diagrams of channels NN 10, 11, 12, 24 and 25 are shown on fig. 3.6, 3.7, 3.8, amplitude-frequency characteristics - on fig. 3.9, 3.10, 3.11, 3.12 and 3.13. Sensors of channels NN 10, 11, 12, 24 and 25 are placed on the instrumental structure on the pedestal. Instrumental structure is removed from technical site N 2 on the distance of 50 m to the east and was carried out in form of vertical shaft with depth equal to 25 m with adit, that branch of from the lowest point with length equal to 7 m and width equal to 3 m. Diameter of shaft is 3 m.

Besides this equipment at the GO " Kurchatov " in 1994 year the seismic station IRIS-IDA was installed, and it is analogous to the station, that was described in chapter 2, point 2.7.1. Seismosensors of station is in the instrumental structure. Amplitude - frequency

characteristic and phase - frequency characteristic of broadband sensor STS-2 are shown on fig. 3.14. Complete archive of records of stations IRIS-IDA take a place since 1994 year.

Magnetometrical and acoustical methods of registration of nuclear explosions and other events, that were connected with anomalies of different kinds were restored and work now in geophysical observatory " Kurchatov " at the technical site N 2. Itinerant weather station is working. The works for registration of radiophysical method of registration of electromagnetical pulses, that arise from ground, air, cosmic nuclear explosions and other physical events are started. Magnetometrical, acoustical and radiophysical methods of registration present a big interest for prediction of earthquakes and studing of their forerunners.

3.7. Examples of digital records of seismic signals from seismic array " Cross " and IRIS-IDA station in Kurchatov.

As the example of seismic signals at the seismic group " Cross " and IRIS-IDA station, we chose several records from the sources with different magnitudes and on the different epicentral distances.

3.7.1. Local seismic signals.

Records of seismic signals on the working channels of SG " Cross " 26.03.96 year at 13:58:19.01 are shown on fig. 3.15. Records of the same signal on the main configuration channels of seismic group (CH02 - northern; CH10 - southern; CH20 - western; CH16 - eastern; CH21 - central) are shown on fig. 3.16. Results of calculations of azimuth and localization of source of signal are shown on fig. 3.17. The coordinates of epicenter are 50.11 N and 77.81 E. Azimuth on the source is 237.97 . Geographically, epicenter was situated in 76 km (0.68) from the center of SG in the region of rock mass called Myrzhik. In the Kurchatov city this earthquake was felt with force 3 by the MKS scale. Upon the data of GO " Borovoe " the magnitude of this earthquake is 5.1, and upon the data of Central seismic station " Almaty " - only 3.7. If the first estimation seems too high, then the second was too under-estimated. Maybe it is connected with highfrequency signal.

Presence of strong enough seismic events in the region of GO " Kurchatov " states a problem of detail research of local seismicity.

3.7.2. Regional seismic signals.

For the study of possibilities of registration of SG " Cross " on the distances of 8 - 30 we chosen the records of several earthquakes.

Seismograms, that were recorded by SG " Cross " at 25 of August 1995 year, are shown on fig. 3.18. In 12:51:29.1 GMT at the Northern Tyan-Shan the earthquake with magnitude $m = 4.2$ was happened. Records of the same event on the main configuration sensors of SG are shown on fig. 3.19 (CH01 - northern; CH10 - southern; CH21 - eastern and central; CH20 - western). Results of calculation for definition of localization of epicenter of event are shown on fig. 3.21. For the comparison, the records of three components of the same signal on GSN-station IRIS/IDA in Kurchatov city are shown on fig. 3.22. The true coordinates of epicenter of event are: $42^{\circ} 29' N$ and $77^{\circ} 23' E$, azimuth is 185.96, epicentral distance is 8.177. Calculated value of azimuth upon the record of SG - 192.78. In the working range of frequencies 0.5 - 5 Hz are several spectral peaks, that were connected with the own noise of seismograph.

Another one record of signal from the earthquake at Northern Tyan-Shan on the working channels of SG " Cross " on 01 Nov 1995 year at 12:29:24.1 GMT is shown on fig. 3.23. Records of the same signal on the main configuration sensors are shown on fig. 3.24 (CH02 - northern; CH10 - southern; CH16 - eastern; CH20 - western; CH21 - central). The results of calculation of localization of epicenter are shown on fig. 3.25. Spectral characteristics of signal (sonogram and spectrogram) are shown on fig. 3.26. Records of three components of the same earthquake on GSN-station IRIS/IDA are shown on fig. 3.27 (BHE - eastern component; BHN - northern; BHZ - vertical). Coordinates of epicenter of event upon the catalogue of earthquakes are $42^{\circ} 51' N$ and $80^{\circ} 13' E$. The magnitude $m = 5.2$. Epicentral distance is 8.45. True azimuth on epicenters 171.48, and our calculated is 146.32. On the spectrogram in the working range of frequencies 0.5 - 5 Hz, after the correction of the instrumental noises several spectral peaks are distinguished: -0.8; 1.8; 2.2; 29.5 Hz.

Records of seismic signal at the SG " Cross " from the earthquake with episentral distance 8.765 are shown on fig. 3.28. Earthquake was happened in the Southern Tyan-Shan on 17 Aug 1995 year at 13:16:44.0 GMT, magnitude of event $m = 4.5$. Records of working configuration channels of SG are shown on fig. 3.29 (CH02 - northern; CH10 - southern; CH16 - eastern; CH20 - western; CH21 - central). Spectral characteristics of control channel N 21 of SG are shown on fig. 3.30. Three-component record of the signal of the same earthquake on GSN-station is shown on fig. 3.31 (BHE - eastern; BHN -

northern; BHZ - vertical component). The spectral power of signal is concentrated mainly in the two peaks at the frequencies 1 and 2 Hz. Coordinates of epicenter are: 43° 54' N, 70° 13' E. Real azimuth of signal arrival is 223.137 , and calculated is 223.29.

Record of signal of the working channels of SG " Cross " for 3 Nov 1995 year is shown on fig. 3.32. The earthquake with magnitude $m = 4.4$ was happened at 11:09:50.9 GMT in Pamir. Records of this signal on the working configuration sensors of group in the more large scale are shown on fig. 3.33 (CH02 - northern; CH10 - southern; CH21 - eastern and central; CH20 - western). Results of calculations for determination of epicenter of earthquake are shown on fig. 3.34. The spectral characteristics of signal of the main channel N 21 of seismic group are shown on fig. 3.35. More broadband record of the same channel on the three-component GSN-station IRIS/IDA is shown on fig. 3.36. Coordinates of this earthquake are: 40° 00' N and 73° 53' E, epicentral distance is 11.103. Azimuth of signal arrival to the SG " Cross " : calculated is 193.796, upon the our data - 203.12.

3.7.3. Records of seismic signals from the teleseismic distances.

Recording of such a signals is characterized by the rough change of correlation signal/noise. This circumstance must to influence on the accuracy of determination of parameters of localization of epicenters. Let see the examples of such records.

Examples of records of seismic signal from the earthquake with magnitude $m = 4.9$ on the working channels of SG " Cross ", the results of calculations for determination of localization of epicenter and spectral characteristics of signal are shown on fig. 3.37, 3.38, 3.39 and 3.40. Earthquake was happened in Iran. Coordinates of event are 28° 28' N and 57° 05' E. Epicentral distance is 27 43. Calculated (ideal) azimuth of signal arrival to the SG is 224.24, and upon the our calculations is 226.23. Specter of signal in comparison with the regional seismic signals is shifted into the range of more low frequencies.

Records of seismic signal from the earthquake with $m = 4.9$ in Yugoslavia on 25 Aug 1995 year at 09:27:19.9 GMT are shown on fig. 3.41, 3.42, 3.43 and 3.44. Coordinates of epicenter of earthquake are: 45° 23' N and 17° 48' E. Epicentral distance is 39.82. Calculated azimuth of signal arrival to the SG " Cross " is 286.9, upon the data of our calculations is 285.02.

Records of seismic signals and the results of it processing on the working channels of SG " Cross " from the earthquake with $m = 5.8$, that was happened in Kamchatka on 1 Jan 1995 year at 09:57:45.7 GMT are shown on fig. 3.45, 3.46, 3.47 and 3.48. Coordinates of event are: 53° 33' N and 159° 58' E. Calculated azimuth of P-wave arrival to the SG " Cross "

equal to 53.05, and upon the data of our calculations is 55.71 (fig. 3.47). Spectral composition of signal (fig. 3.48) is shifted into the range of low frequencies (the main peak is on 0.7 Hz), what is connected with the good study in the records of ground wave arrival (fig. 3.45 and 3.46). Epicentral distance is 47.32.

Examples of records of the signal from the epicentral distance 60.58 on the working channels of SG " Cross " are shown on fig. 3.49, 3.50, 3.51. The earthquake with $m = 4.9$ was happened in the water area of Atlantic ocean on 24 Oct 1995 year at 14:39:32.4 GMT. Coordinates of epicenter are: $52^{\circ} 26' N$ and $29^{\circ} 52' W$. Calculated azimuth of seismic wave arrival to the SG " Cross " equal to 318.44, and upon the data of calculations it is equal to 317.99 (fig. 3.51).

Record of signals and results of their interpretation from the earthquake at the Sulavesi island in Indonesia are shown on fig. 3.52, 3.53, 3.54, 3.55. The earthquake with $m = 6.0$ was happened on 1 Jan 1996 year at 08:05:06.7. Coordinates of epicenter are: $00^{\circ} 32' N$ and $120^{\circ} 02' E$. Epicentral distance is 61.163. Calculated azimuth of seismic wave arrival to the SG is equal to 130.85, and upon the data of our calculations it is equal to 142.85 (fig. 3.54). Maximum amplitude of signal is observed on the frequency of 0.7 Hz.

Records of seismic signal from the earthquake with $m = 4.6$ are shown on fig. 3.56, 3.57, 3.58 and 3.59. The earthquake was happened in the Indian ocean on 27 Aug 1995 year at 16:27:54.0 GMT. Coordinates of epicenter are: $25^{\circ} 50' S$ and $69^{\circ} 16' E$. Epicentral distance equal to 76.89. Calculated azimuth of seismic wave arrival to the SG equal to 188.56, and upon our determination it is equal to 202.2 (fig. 3.58). The spectral features of signal in the working range of frequencies are determined not enough clearly (fig. 3.59).

At last, example of record of another one teleseismic signal is shown on fig. 3.60 and 3.61. Results of calculations of parameters of localization of epicenter and spectral characteristics of this signal are shown on fig. 3.62 and 3.63. The earthquake with $m = 6.8$ was happened in Mexico on 2 Aug 1995 year at 10:46:15.7 GMT. Coordinates of earthquake are: $26^{\circ} 32' N$ and $111^{\circ} 05' W$. Epicentral distance is 102 38. Calculated azimuth of seismic wave arrival to the SG " Cross " equal to 8.8. Real azimuth, that was produced from our calculations equal to 346.83. Maximum amplitudes in the specter of signal are concentrated in the range of low frequencies (below 0.65 Hz).

4. Conclusion.

Results of carried out work are consisted in following:

1. History of geophysical observatories " Borovoe " and " Kurchatov " was restored and described.
2. Different kinds of apparatus of geophysical observatories, both working now and that was used in the past, were described.
3. Access of records of seismic events on the different kinds of apparatus was created.
4. Inventory of arcvives at GO " Kurchatov " and " Borovoe " was carried out.

We hope, that the present report can help to the interested researchers to take there's bearing better in the possibilities of geophysical observatories of Institute of Geophysical Researches of NNC of RK.

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REGION 11

Ambient Earth's Noise at BRVK STS-2

Рисунок 2.1

Рисунок 2.2

SCHEMA OF TECHNICAL BUILDINGS LOCATION AT GO "BORDVOYE"

1	Technical building N1	10	Borehole-above structure
2	Technical building N2	11	Borehole N5
3	Technical building N3	12	Borehole N6
4	Shaft	13	Borehole N7
5	Tunnel	14	Borehole N8
6	Borehole N1	15	Borehole N9
7	Borehole N2	16	Borehole N10
8	Borehole N3		
9	Borehole N4		

— Communication line

Рисунок 2.3

Рисунок 2.4

Рисунок 2.5

Рисунок 2.6

Рисунок 2.7

Рисунок 2.8

Рисунок 2.9

Рисунок 2.10

Рисунок 2.11

Рисунок 2.12

Рисунок 2.13

Рисунок 2.14

Рисунок 2.15

Рисунок 2.16

Рисунок 2.17

CMG-3 RESPONSE

Рисунок 2.18

Event: 1994/ 7/22 8: 0:49.592 0.000 0.000 h= 0.0 km Local Event (15 - 20 km)

P S Rg

BRVK Z
2.86E-03
8: 0:54.59

BRVK NS
2.26E-03
8: 0:54.59

BRVK EW
1.39E-03
8: 0:54.59

Рисунок 2.19

Рисунок 2.20

Event: 1994/07/21, 18:36:31.6, (42.28°N, 132.88°E), h=473 km, mb=6.6, Russia, Far East

Рисунок 2.21

Mururoa 1995

Рисунок 2.22

Рисунок 2.23

Рисунок 2.24

Рисунок 2.25

$R_{\text{ср.}} = 2978 \text{ м.}$

НУП	4	5	6	7	8	9
$\Delta R \%$	-4,5	-1,9	+8,2	+2,0	-3,2	-0,6

Рисунок 2.26

$R_{\text{ср.}} = 2900 \text{ м.}$

НЧП	4	5	ПС	7	8	9
$\Delta R \%$	-0,2	+1,7	+1,5	+3,5	+3,6	-10,1

Рисунок 2.27

$R_{cp} = 2879 \text{ м.}$

НУП	4	5	6	7	8	9
$\Delta R \%$	-2,2	-0,1	+2,4	+7,4	+0,2	-7,6

Рисунок 2.28

Рисунок 2.29

Рисунок 2.30

Рисунок 2.31

Ambient Earth's Noise at KUR

Рисунок 3.1

Условные обозначения:

- грунтовая дорога
- == шоссе
- НУП
- +— линии электропередач
- трубопровод
- +— железная дорога

Рисунок 3.2

Рисунок 3.3

$K_{\text{ц}}$ — амплитудно-частотные характеристики центрального канала
 $K_{\text{с}}$ — суммарного канала
 $K_{\text{сф}}$ — канала с фильтром

H-213-S RESPONSE

Рисунок 3.4

PARUS INSTRUMENT RESPONSE

Рисунок 3.6

Рисунок 3.7

СВК-Д

КСВ-М

Рисунок 3.8

Рисунок 3.9

Рисунок 3.11

Частота, Гц

Рисунок 3.13

STS-2 RESPONSE

Рисунок 3.14

Рисунок 3.15

Filter: None, Amp: Auto

JSPC dbpick: C95086 local1c.ps marina Tue May 21 03:27:51 1996

Рисунок 3.16

Filter: None, Amp: Auto

JSPC dbpick: C95086 local1cs.ps marina Tue May 21 03:28:28 1996

KURX CH21 SPZ Azimuth = 237.97

KURX CH21 SPZ az = 237.97, v = 6.20

Normalized Beam Power

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Рисунок 3.18

Filter: None, Amp: Auto

JSPC dbpick: C95237 aalc.ps marina Tue May 21 09:56:07 1996

Рисунок 3.19

Filter: None, Amp: Auto

JSPC dbpick: C95237 aa1cs.ps marina Tue May 21 09:58:38 1996

KURX CH21 SPZ Azimuth = 192.78

KURX CH21 SPZ az = 192.78, v = 8.87

Normalized Beam Power

Рисунок 3.20

Рисунок 3.21

larina Thu May 30 03:05:46 1996

3.72

Рисунок 3.22

Filter: None, Amp: Auto

JSPC dbpick: css aa1.ps ida Fri Apr 26 03:23:38 1996

Рисунок 3.23

Filter: None, Amp: Auto1

JSPC dbpick: C95305 aa2c.ps marina Mon May 20 03:32:10 1996

Рисунок 3.24

Filter: None, Amp: AutoI

JSPC dbpick: C95305 aa2cs.ps marina Mon May 20 03:32:59 1996

KURX CH21 SPZ Azimuth = 146.32

KURX CH21 SPZ az = 146.32, v = 6.82

Рисунок 3.25

31.17.dbbeam.ps marina Thu May 30 03:30:14 1996

thalf = 1.30

Instrument Correction: K-213-S

Рисунок 3.26

arina Thu May 30 03:27:06 1996

Filter: None, Amp: Auto1

Рисунок 3.27

29 09:22:18 1996

Filter: None, Amp: Auto1

Рисунок 3.28

ina Fri May 17 10:09:58 1996

3,24

Filter: None, Amp: Auto1

Рисунок 3.29

ina Fri May 17 10:10:46 1996

3, 26

Instrument Correction: K-213-S

Рисунок 3.30

harina Thu May 30 09:29:58 1996

3,27

Filter: None, Amp: Auto1

Рисунок 3.31

Apr 25 04:22:54 1996

Filter: None. Amp: Auto

Рисунок 3.32

narina Mon May 20 08:36:03 1996

Рисунок 3.33

KURX CH21 SPZ Azimuth = 203.12

KURX CH21 SPZ az = 203.12, v = 8.70

Normalized Beam Power

Рисунок 3.34

3,35

thalf = 3.00

Instrument Correction: K-213-S

Рисунок 3.35

pr marina Thu May 30 09:23:00 1996

Filter: None, Amp: Auto1

Рисунок 3.36

on Apr 29 09:48:47 1996

Filter: None, Amp: Auto

Рисунок 3.37

ina Thu Jun 13 02:38:24 1996

Filter: None, Amp: Auto

Рисунок 3.38

arina Thu Jun 13 02:39:28 1996

KURX CH21 SPZ Azimuth = 226.23

KURX CH21 SPZ az = 226.23, v = 12.59

Normalized Beam Power

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Рисунок 3.39

8.40.dbbeam.ps marina Thu Jun 13 02:46:23 1996

Instrument Correction: K-213-S

Рисунок 3.40

arina Thu Jun 13 03:47:56 1996

Filter: None, Amp: Auto

Рисунок 3.41

arina Thu Jun 13 04:00:27 1996

Filter: None, Amp: Auto

Рисунок 3.42

arina Thu Jun 13 04:01:37 1996

KURX CH21 SPZ Azimuth = 285.02

KURX CH21 SPZ az = 285.02, v = 11.77

Normalized Beam Power

Рисунок 3.43

1.34.55.dbbeam.ps marina Thu Jun 13 04:04:31 1996

Instrument Correction: K-213-S

Рисунок 3.44

r marina Thu Jun 13 04:06:51 1996

Filter: None, Amp: Auto

Рисунок 3.45

marina Wed May 29 07:37:44 1996

Filter: None, Amp: Auto

Рисунок 3.46

ps marina Wed May 29 07:36:22 1996

KURX CH21 SPZ Azimuth = 55.71

KURX CH21 SPZ az = 55.71, v = 14.51

Normalized Beam Power

Рисунок 3.47

06.20.dbbeam.ps marina Wed May 29 03:34:36 1996

Instrument Correction: K-213-S

Рисунок 3.48

c.spr marina Wed May 29 07:44:46 1996

Filter: None, Amp: Auto

Рисунок 3.49

narina Wed Jun 12 05:04:35 1996

Filter: None, Amp: Auto

Рисунок 3.50

rina Wed Jun 12 05:03:23 1996

KURX CH21 SPZ Azimuth = 317.99

KURX CH21 SPZ az = 317.99, v = 14.89

Normalized Beam Power

Рисунок 3.51

19.45.dbbeam.ps marina Wed Jun 12 05:01:23 1996

3.75

Filter: None, Amp: Auto

Рисунок 3.52

arina Thu May 30 08:35:28 1996

3.76

Filter: None, Amp: Auto

Рисунок 3.53

narina Thu May 30 08:36:14 1996

KURX CH21 SPZ Azimuth = 142.85

KURX CH21 SPZ az = 142.85, v = 19.46

Normalized Beam Power

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Рисунок 3.54

Frequency (hz)

thalf = 3.00

Instrument Correction: K-213-S

Рисунок 3.55

marina Thu May 30 08:43:05 1996

Filter: None, Amp: Auto

Рисунок 3.56

s marina Thu Jun 13 04:34:14 1996

Filter: None, Amp: Auto

Рисунок 3.57

ps marina Thu Jun 13 04:36:03 1996

KURX CH21 SPZ Azimuth = 202.20

KURX CH21 SPZ az = 202.20, v = 17.71

Normalized Beam Power

Рисунок 3.58

39.48.dbbeam.ps marina Thu Jun 13 04:17:41 1996

thalf = 4.50

Instrument Correction: K-213-S

Рисунок 3.59

n.spr marina Thu Jun 13 04:23:40 1996

Filter: None, Amp: Auto

Рисунок 3.60

narina Thu Jun 13 04:46:36 1996

Filter: None, Amp: Auto

Рисунок 3.61

marina Thu Jun 13 04:49:05 1996

KURX CH21 SPZ Azimuth = 346.83

KURX CH21 SPZ az = 346.83, v = 26.16

Normalized Beam Power

Рисунок 3.62

3.86-

Instrument Correction: K-213-S

Рисунок 3.6 3

т marina Thu Jun 13 05:00:37 1996