MODERNIZATION OF SEISMOLOGICAL OBSERVATION NETWORK OF DAGESTAN

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This article represents the dynamics of the development of instrumental seismic observations in the Dagestan territory, analogue and digital seismic recording systems equipment. The current status of the seismic observation network and the modernization stages are examined in this work.

Key words: seismic observation, analog and digital seismic recording systems.

The territory of Dagestan belongs to the most seismically active region of the European part of Russia. In the historical past, and in recent years, there were strong and destructive earthquakes in the territory of Dagestan.

The first continuous instrumental seismological observations in the territory of Dagestan started from the beginning of the 1050's with the Institute of Physics of the Earth in Makhachkala in 1951.

The destructive Dagestan earthquake on May 14, 1970 ($M=6,6$ $J_0=9$) saw the start of the large-scale instrumental survey, then the network of seismic stations of the Dagestan branch of the Academy of Sciences of the USSR started developing in Dagestan (5 stationary and one field seismic station).

Prior to a seismic station in Makhachkala, the instrumental parameters of earthquakes occurring in the territory of Dagestan and the bordering republics were determined on the basis of registration data of the Transcaucasia seismic station network.

The test survey seismological expeditions and crews were formed in the Academy of Sciences USSR for the improvement of instrumental seismological supervision systems in the territory of the USSR in 1979. One of these crews was formed at the Dagestan branch of the Academy of Sciences of the USSR with the assignment of 5 seismic stations of the Geological Institute of the Dagestan Branch of the Academy of Sciences of the USSR [1].

In 1994, on the basis of experimental methodical expeditions the Geophysical Survey of the Russian Academy of Sciences was created. The main task was continuous seismological monitoring of the territory of Russia and its different regions, seismic risk zoning, earthquake forecasting with early notification of the central, local executive authorities and the interested departments and organizations interested in seismic events as they occurred.

The Dagestan Branch of the Geophysical Survey of the Russian Academy of Sciences controls the seismic stations in the one of the most seismically active regions of the country where the earthquake intensities rise to 9, and by nature and scale of soil paleoseismic dislocation is more than 9 [2].

The object of the Dagestan branch GS RAS research is to consider an earthquake in several aspects, the main are: the seismic setting, the seismic hazard level and the seismogenesis nature (including the nature of "technogenic" earthquakes). Also, the changes of the physical, geochemical and other fields associated with earthquake preparation, which are considered as precursors with orientation on subsequent forecasting of earthquakes are studied [3].

A network of seismic observations which let us register seismic events of various scales has now been developed in the territory of Dagestan.

16 seismic stations, 1 geochemical and 2 geophysical stations and observation points were used within DB GS RAS for carrying out seismological and other observations to study the seismic setting of the Dagestan territory and bordering regions, and also for the earthquake precursor research.

The DB GS RAS observation network plan is given on fig. 1.

The measurements of gas components such as helium, hydrogen, nitrogen and oxygen are taken at geochemical stations, and also productivity and temperature changes of the self-pumping water from a well and hydrogen content variations at the terrestrial atmosphere.

Seismic analogue stations of the observation network were equipped with standard sets of equipment for photo-galvanometric recording on the basis of the register RS-II M and the seismometers of the SKM-3 type.

There were three analogue stations in the middle of 2015. The equipment of analogue seismic stations and the rate of channel increase are shown in table No. 1.

The instrumental seismological observations are made by means of an analogue record on photographic paper with change of seismographic records twice per day, and by means of digital seismic stations [4].

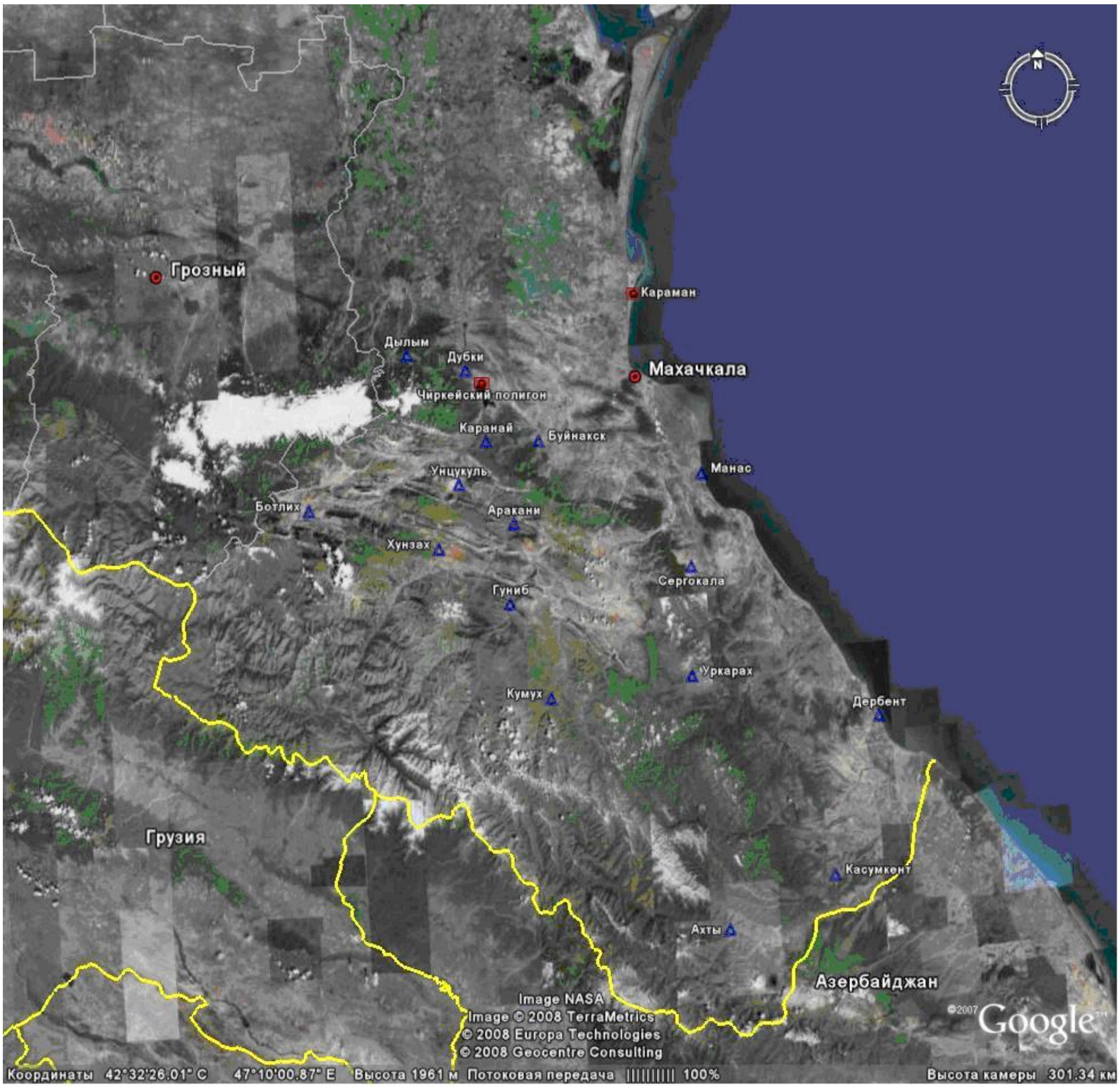

Fig.1. The location of the observation network DB GS RAS.

Table №1

Analogue stations and value of channel increase

№	Station Code	coordinates h,m		Type of instruments			Comp	Y_{max}	T_{max}	Opening Date
		$\varphi, ^0N$	$\lambda, ^0E$	Register.	Galv.	Seism. receiver				
1	Kasumkent KSMR	41.6023 930м	48.1246	PC-II	M- 1031	SKM-3 SKM-3 SKM-3	Z N E	11752 10271 104	0.15-0.75 0.15-0.8 0.15-0.9	01.10. 1987г.
2	Kumukh KMKR	42.1287 1895м	47,0977	PC-II	ГК- VII	SKM-3 SKM-3 SKM-3	Z N E	17313 18340 239	0.15-0.8 0.3-0.7 0.2-0.7	01.04. 1985г.
3	Untsukul UNCR	42.7155 780м	46.7929	PC-II	M- 1031	SKM-3 SKM-3 SKM-3	Z N E	15917 15366 392	0.2-1.1 0.2-1.1 0.2-1.2	01.02. 1984г.

The detailed data on parameters of the seismo-receivers and galvanometers used on stationary seismic stations and at the organization of expedition in the epicentral area are given in tables No. 2 and No. 3.

Table №2

Seismic receiver parameters

type	Ls	Ks	Rsg	Rsd	Ssg	Ssd	αsg	αsd	Ts
SM-3	0.085	0.009	55	55	12- 18	12-18	10-21	10-21	<2
SM-3V	0.085	0.009	2000	50	130	12- 18	1120	10-21	<2
SKM-3	0.165	0.305	50	50	90- 100	90-100	60-80	60-80	<2

Tale №3

Galvanometer parameters

Galv. type	Tg	Fg	Sg	Pg-8	R_g	Rкр	A	Application
M1031/1	1.2	0.83	77000	1.3	49	850	1	
M1031/2	0.6	1.66	83000	1.2	82	320	-	
M1031/3 M1031/4	0.4 0.3	2.5 3.33	40000 22000	2.5 4.5	75 72	200 135	-	register RS-2
GB-S-3	0.2	5	45000	2.2	150	3400	-	N700 N041
GB-III-B-5	0.2	5	17000	5.8	58	1500	-	OSB-6

A three-component record at two sensitivity levels is kept on all seismic stations. The channel with E-W orientation is chosen as the channel of hypo-sensitivity. The channels oriented on N-S and Z are adjusted on high sensitivity with rates of increase close to each other. The maximum factor value of channel increase is limited by the technical capabilities of seismic monitoring equipment on the one hand, (application of a set OSB-6 and SM-3kv, and increase coefficient $V \leq 7000$ at the level of $0{,}9V_0$), and the level of microseismic noise suppressing a useful signal on the other hand [5].

We made preparations on measurements of microseisms general background in the selected area to choose a location for the seismic station pedestal.

Time markers are put on seismograms with the help a of special GPS timer for analogue seismic stations.

There has been considerable changes in the seismic observation system on the Dagestan territory over recent decades.

Following the program of observation network modernization, with the aim of improving the informational quality of received seismic information, the number of digital seismic stations reached 16, and by the end of 2015 they completely replaced analogue stations with galvanic entry form. Digital stations of SDAS and UGRA type let us record the data in continuous mode on three channels. Dynamic range of seismic events record 96 dB (16 categories coder) for SDAS station and 120 dB (24 categories coder) for UGRA station, frequency range is 0-30 Hz. Sampling frequency at digitizing is set from 20 to 100 count / sec. [4; 6].

All digital stations are connected to the internet and transfer information to the processing center in real time.

Dynamics of modernization of an observation network of Dagestan is shown in table 4 and in fig. 2.

Table 4

The number of seismic stations of Dagestan observational network.

Years / Stations	2007	2008	2009	2010	2011	2012	2013	2014	2015
Analogue	16	14	14	11	10	9	8	3	-
Digital	-	2	2	5	6	7	9	13	16

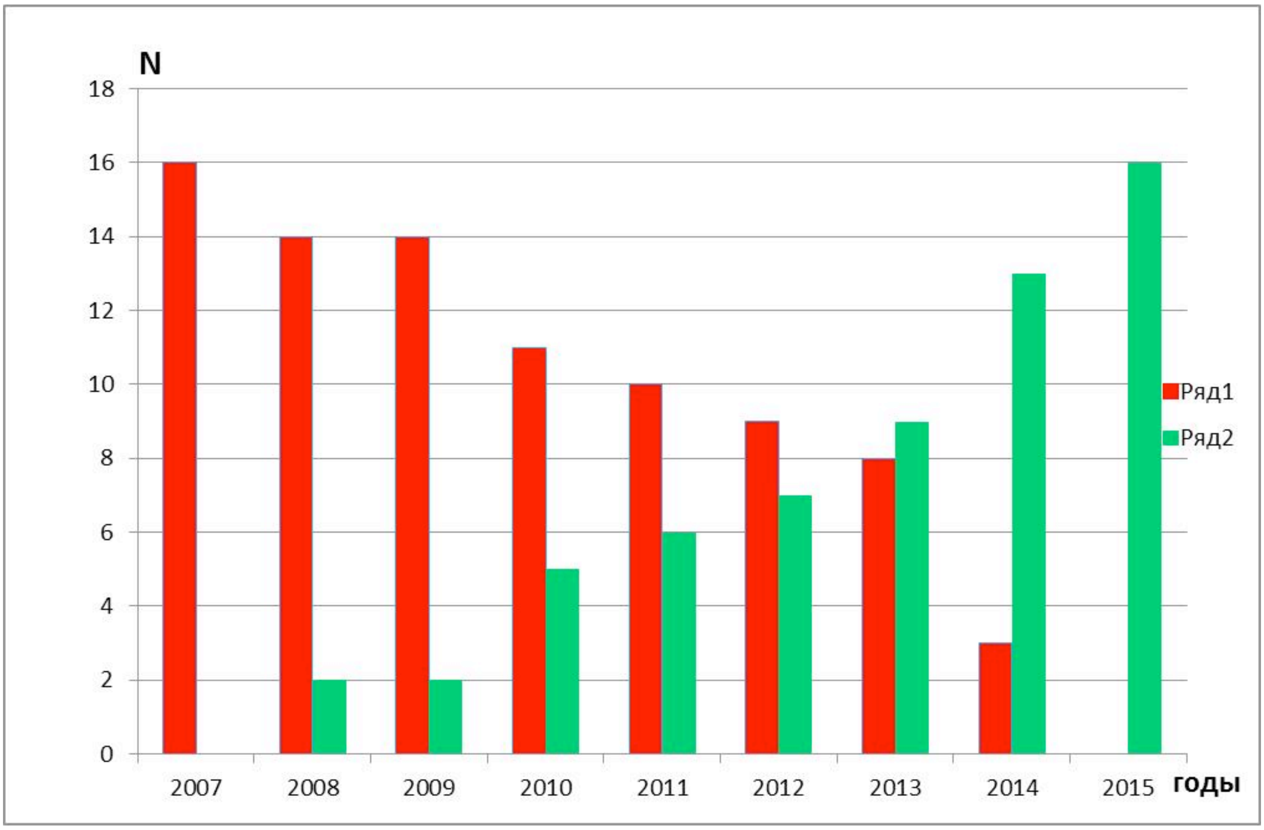

Fig. 2. The pace of modernization of DB GS RAS observation network.

N – number of seismic stations;
row 1 – analogue seismic stations;
row 2 - digital seismic stations

The brief characteristics and place of installation of digital seismic stations is shown in the table №5.

Table №5

Digital seismic station equipment

№	Station Code.	Coordinates, h, m		Type of instrument	List of channels	Frequ ency	Samples Per sec.	Coder caterg	Open. date
		φ, ^{0}N	λ, ^{0}E						
1	Dubki DBC	43.0216 850м	46.8410	SDAS CM3-кв	SH(NZE) SL(NZE)	0.5-30 0.5-30	40 40	16 16	01.11. 2008г.
2	Gunib GNBR	42.3893 1210м	46.9638	SDAS CM3-кв	SH(NZE) SL(NZE)	0.5-30 0.5-30	40 40	16 16	19.09. 2008г.

3	Botlikh BTLR	42.6653 970м	46.2192	UGRA SM3-kv	SHN SHZ SHE	0.5-30 0.5-30 0.5-30	50 50 50	24 24 24	28.06. 2010г.
4	Akhty AKT	41.4793 1115м	47.7148	UGRA SM3-kv	SHN SHZ SHE	0.5-30 0.5-30 0.5-30	50 50 50	24 24 24	17.10. 2010г.
5	Derbent DRN	42.0204 -20м	48.3318	UGRA SM3-kv	SHN SHZ SHE	0.5-30 0.5-30 0.5-30	50 50 50	24 24 24	02.09. 2010г.
6	Khunzakh XNZR	42.5451 1680м	46.7053	UGRA SM3-kv	SHN SHZ SHE	0.5-30 0.5-30 0.5-30	50 50 50	24 24 24	21.07. 2011г.
7	Urkarakh URKR	42.1649 1330м	47.6310	UGRA SM3-kv	SHN SHZ SHE	0.5-30 0.5-30 0.5-30	50 50 50	24 24 24	20.06. 2012г.
8	Bujnaksk BUJR	42.8208 480м	47.1039	UGRA SM3-kv	SHN SHZ SHE	0.5-30 0.5-30 0.5-30	50 50 50	24 24 24	14.06. 2013г.
9	Karaman KANR	43.196 -25м	47.489	UGRA SM3-kv	SHN SHZ SHE	0.5-30 0.5-30 0.5-30	50 50 50	24 24 24	01.12. 2013г.
10	Sergokala SGKR	42, 4576 560 м	47,6556	UGRA SKM-3	SHN SHZ SHE	0,5-30 0,5-30 0,5-30	50 50 50	24 24 24	06.11. 2014 г.
11	Dylym DLMR	43,0730 660 м	46,6187	UGRA SKM-3	SHN SHZ SHE	0,5-30 0,5-30 0,5-30	50 50 50	24 24 24	12.11 2014 г.
12	Karanay KRNR	42,8267 1250 м	46,9053	UGRA SKM-3	SHN SHZ SHE	0,5-30 0,5-30 0,5-30	50 50 50	24 24 24	19.11. 2014 г.
13	Arakani ARKR	42,6021 760 м	46,9942	UGRA SKM-3	SHN SHZ SHE	0,5-30 0,5-30 0,5-30	50 50 50	24 24 24	20.11. 2014 г.
14	Kasumkent KSMR	41,6023 930м	48,1246	UGRA SKM-3	SHN SHZ SHE	0,5-30 0,5-30 0,5-30	50 50 50	24 24 24	16.06 2015г.
15	Untsukul UNCR	42,7155 780м	46,7929	UGRA SKM-3	SHN SHZ SHE	0,5-30 0,5-30 0,5-30	50 50 50	24 24 24	01.08 2015г.
16	Kumukh KMKR	42,1287 1895м	47,0977	UGRA SKM-3	SHN SHZ SHE	0,5-30 0,5-30 0,5-30	50 50 50	24 24 24	21.10 2015г.

Conclusions

With digitization of seismic events record, there are further possibilities for studying the moderate and low-magnitude seismicity of the region, and the level of reliable earthquake registration will come to K≥6, except for several areas of the adjacent Georgia and Azerbaijan territory.

With the help of the digital recording of seismic events during a short period of time the total characteristic of seismic events for Dagestan and adjacent territories will be received, the quality of seismic data will be improved considerably, and the potential opportunities for the analysis of the received data will be extended.

The equipment modernization with digitization will lead to sensitivity enhancement of some stations, not less than 10%. It will increase the signal/noise relation with the help of strip filters and the polarized record analysis selected for each station.

Modernization of an observation network is necessary not only for increase of network sensitivity, improvement of accuracy of the determined parameters of earthquakes, but also for acceleration of the process of receiving earthquakes values that is extremely important for the fast response of rescue services during destructive earthquakes.

The new sensitive network will provide an increased reliability of the earth's interior research that is linked to earthquake forecasting.

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