Experience in establishment of the automatic seismological network OJSC "RusHydro" – "Dagestan Branch"

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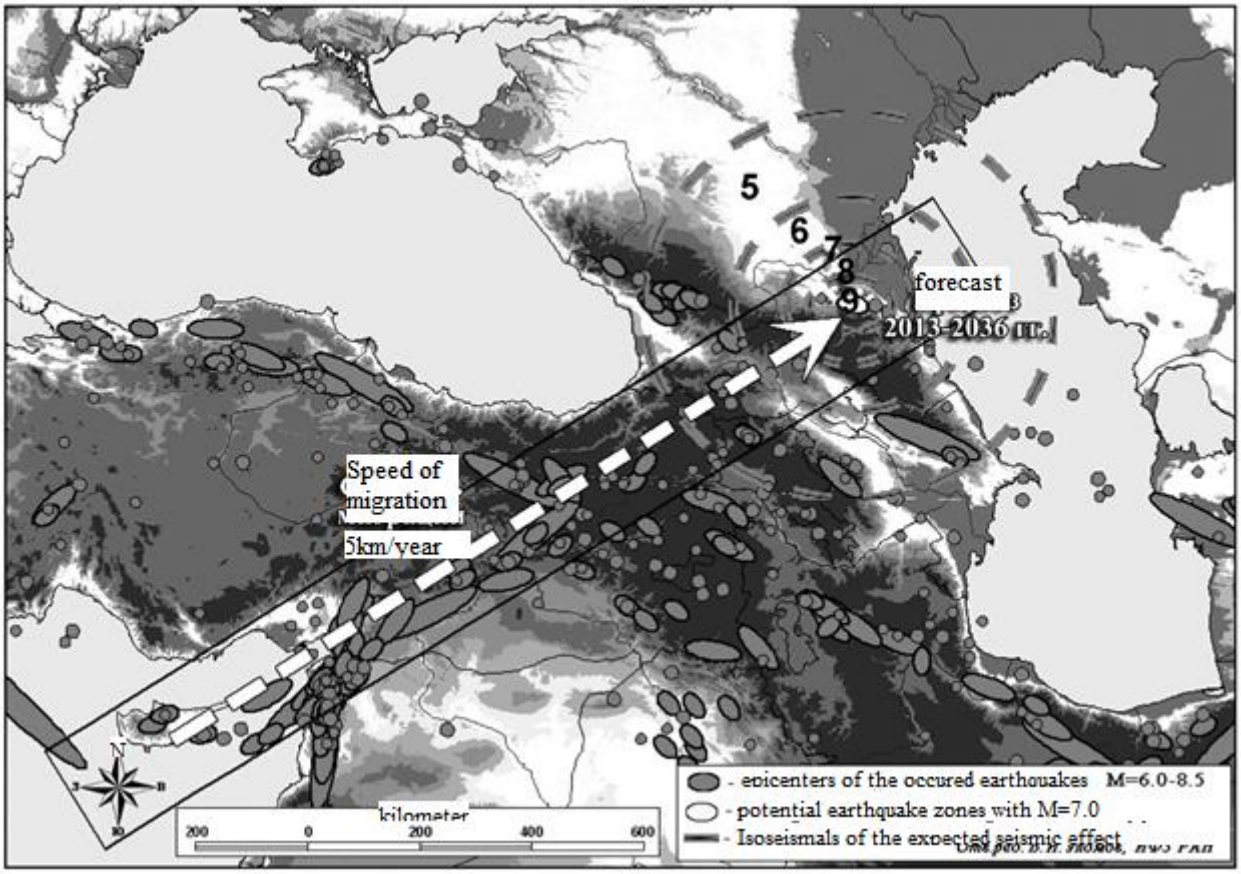
Abstract. Experience in establishment of the automatic seismological network in the Republic of Dagestan, Russia is represented for seismic monitoring of Sulak's DAM reservoirs.

The territory of the Dagestan Republic, Russia is located at the east part of the Northen Caucasus in the long Crimea-Caucasus-Copetdagsk zone of the Iran-Caucasus-Anatoliysk seismic active region. This region is well known by it's earthquakes with seismic effect at the epicenter with value of intensity I0=9 points and more with regards to 12-points macroseismic measuring scale [1].

We'd like to mention some of the biggest seismic events which took place in the Dagestan Republic. Earthquake which is happened 1830 year (M=6.3, I0=8-9 points) and in 1970 year (M=6.6, I0=8-9 points). Like it mentioned in [2], at the nearest years there are expected earthquakes with M=7.0±0.2 (picture 1), about events with M=8.0±0.2 it's difficult to say at the moment. At the picture 1 you can see section Cyprys-Caucasus marked with rectangle, dotted line with arrow shows the migration process of the seismic activity along the section marked with rectangular for the last 200 years.

Isoseismals of the seismic effect are shown by the author of the map [2] at the idealized form as concentric circles, between them is shown the average value of the seismic intensity in points which have been got by calculations. It's shown that seismic effect in the epicenter can get up to 9 points. Earthquakes with intensity 3-4 points can be felt at the whole territory of the Caucasus, with intensity 3 or less points – far outside of the territory of Caucasus in Crimea, North Iran, on the west of the Turkey and Turkmenistan. Such event can take place between 2013 – 2036 years [2].

In Dagestan Republic, Russia there are 8 big and 7 small Hydro-Power Stations of the Dagestan Branch of the Public Joint Stock Company "RusHydro" with total power 1785.5MW, which play the main role for the power safety of the europe part of the Russia, and particularly for Dagestan Republic, Russia [3]. At the moment there are a list of federal and industry regulations which describes how to conduct different explorations and monitoring for safe functionality of the hydro-technical constructions. We'd like to mention: GOST R 22 1.11-2002 "Safety during emergency situations. Monitoring of the state of the hydro-technical constructions (DAMs) and prediction of the possible consequences of the hydro-dynamic accidents on them. General requirements"; Standard of the Organization 70238424.27.140.032-2009 "Hydro-electro stations in the regions with high seismic activity. Geodynamic monitoring of the hydro-technical constructions. Standards and requirements" and others. For the purposes of increasing safety of the hydro-technical constructions (HTC) related to expectations of the strong earthquakes in the region, for monitoring of the seismicity of the region in the area of the DAMs and reservoirs, for the purposes of reducing the risks of the emergency situations there was made a decision to establish automatic seismological monitoring system in order to look at the seismicity of the region of Irganskaya DAM, Miatlinskaya DAM, Gerbilskaya DAM, Gunibskaya DAM, Chirurtskaya DAM-1, Chirurtskaya DAM-2 and Gelbakhskaya DAM.



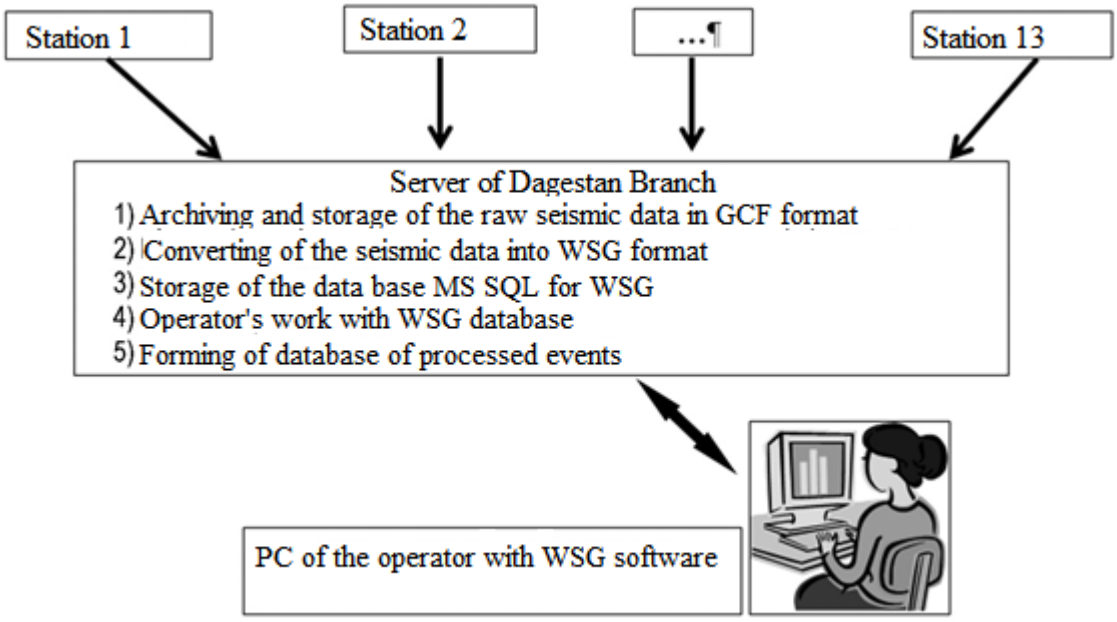
Pic. 1. **Expected seismic effect from one of the potential earthquake centers with M=7.0 (6.8-7.2) at the eastern part of the North Caucasus [2]**

On the stage of pre-works there were conducted engineering and seismological observations as on existing stations of the Dagestan Branch and on the new places which were selected for installation of the new stations by the specialists of the Center Survey of the geodynamic observations in the electric-power industry – branch Open Joint Stock Company "Institute HydroProject" jointly with specialists from Dagestan Branch of Geophysical Survey [4].

During 2015 there were conducted installation and commissioning works for the Seismological Monitoring System. Seismological Monitoring System has been integrated into the Hydro-Technical Constructions Monitoring System for purposes of OJSC "RusHydro" – "Dagestan Branch". Seismological Monitoring System consists of 13 stations (picture 2), which equipped with broadband digital seismometers CMG-6TD (Guralp Systems, UK), and has 2 centers for data processing. First center is for showing seismological situation and it's located in the head-quarters of the Branch OJSC "RusHydro" – "Dagestan Branch", city Kaspiysk. Second center is for gathering and analyzing of the seismological data and it has been founded on the basis of the existing equipment and software of the Dagestan Branch of Geophysical Survey, city Mahachkala. On picture 3 there is shown scheme of the transmitting of the raw seismic data for processing in the WSG software (WSG is used as main software in Geophysical Survey of Russian Academy of Science).

Purposes of the establishing of the system determines features of the system of the information support for Seismological Monitoring System. The main issues are unstable electric power supply and unstable data transmitting channels. In order to resolve these issues were conducted works which provide maximum autonomous and remote access for seismic stations.

Pic. 2. **Scheme of the location of the seismic station for Seismological Monitoring System (white triangles)**



Pic. 3. **Scheme of the transmitting of the raw data to the Dagestan Branch of GS RAS**

One the functions for CMG-6TD is possibility to use TCP or UDP protocol for transmitting data over Internet. For establishing connection between stations and data server TCP protocol has been chosen as more reliable than UDP, as TCP excludes data loss, overlapping, mixing and delays of the data packets. The necessary requirement is to have static IP address on each seismic station with regards to features of the digitizers inside of CMG-6TD. This fact was complicated by poorly developed network infrastructure of some of the regions of the republic, and it also makes Internet access more expensive. In order to avoid data loss during gaps in data transmitting FIFO data recording option is used. Data is recorded in the internal memory of the CMG-6TD and then data is sent to the server for data gathering. When connection is established again then data transmitting automatically starts after last failure. If the mains power works unstable there is provided power from accumulator batteries which let seismic station to work during a week.

For connection of the instruments CMG-6TD to the Internet on the all seismic station were installed router manufactured by MicroTik because of economical and technical parameters. During gathering of the seismological data on the server of Dagestan Branch GS RAS the data is automatically converted into Data Base WSG, archived on the server and on the server storage. For these purposes we has developed special scripts in console variant and converter from GCF into WSG format.

Main data formats which are used in Seismological Monitoring System:

- Raw seismic data in GCF format (Guralp Compressed Format),
- Parameters of the State-Of-Health information provided in .txt format,
- Data in WSG format (which is converted from GCF) used by the WSG software for viewing and processing seismological data.

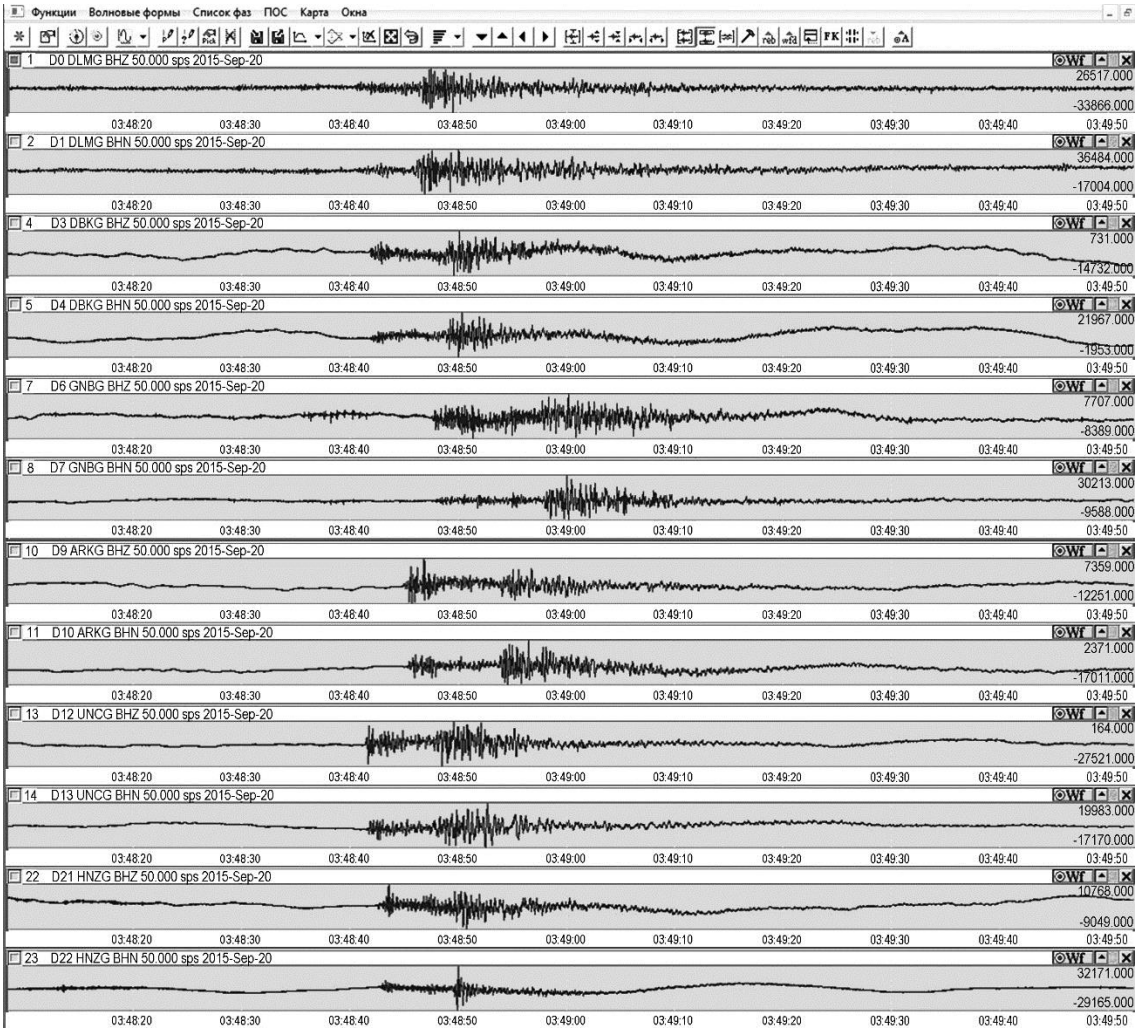
GCF format was chosen because of the compact size of the files if compare, for example, with widely used miniSEED format. Also, CMG-6TD hasn’t possibility to transmit data over SeedLink protocol.

Microsoft SQL Server 2008 R2 is used as the main control system for seismological data base of WSG software. Seismic data in GCF format is archived and saved on the server and on the server storage. Archives of the data contain data for one day, folders are divided by stations, years and months, which provides comfortable access to the data base.

Data displaying of the Seismological Monitoring System is configured for online monitoring on any device (PC/Laptop/Smartphone) in order to provide remote control for seismic situation in the region.

On the picture 4 is shown example of the record of the local earthquake registered by Seismological Monitoring System which happened in Dagestan Republic, Russia 20 september 2015, t0=03:48:31.39, lat=42.821, lon=46.224, k=8.208 (data is shown from 6 stations).

Thus, the developed system allows to perform monitoring of seismicity of the region with DAMs. Taking into account that system covers cascade of DAMs, in this case we have possibility to resolve questions of the interaction between seismicity and processes of the water release on the DAMs.



Pic. 4. Example of the record of the local earthquake registered by Seismological Monitoring System which happened in Dagestan Republic, Russia 20 september 2015, t0=03:48:31.39, lat=42.821, lon=46.224, k=8.208 (data is shown from 6 stations)

LIST OF THE USED LITERATURE

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