Seismic Network of Georgia
Past, Present and Future

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Introduction

Georgia is situated in Caucasus region, between the Black and Caspian Seas. It is one of the most seismically active regions in Alpine-Himalayan collision belt. The main seismotectonic feature is the junction between the Arabian and Eurasian plates. The analysis of the historical and instrumental seismological shows, that this is the region of moderate seismicity. The strong earthquakes with magnitude up to 7 and macrosiesmic intensity 9 (MSK scale) occurred here. Caucasus is characterized with so-called moderate seismisity. Reoccurrence period for strong events is of order of 1000 years. In this case possibility to stretch catalogue of strong events (instrumental records) down to the beginning of 20th century is very important for seismic study of the region (***Fig. 1***).

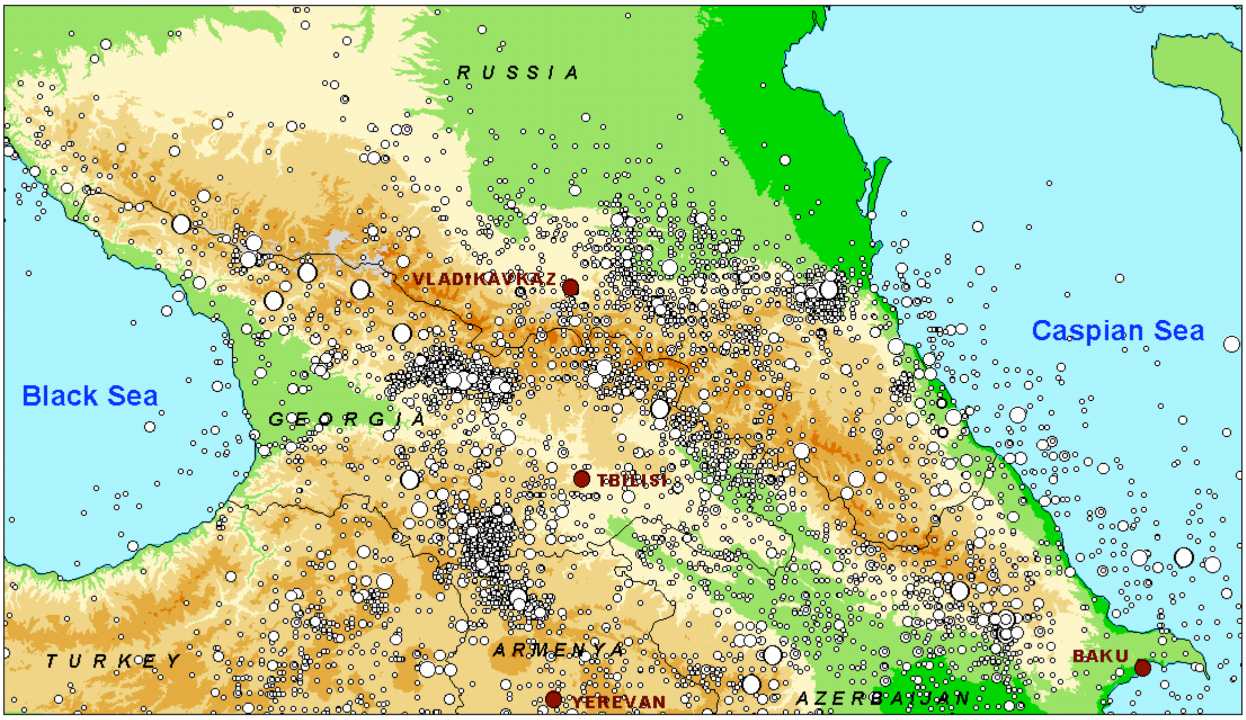

Fig 1. Seismicity map of the Caucasus

Documentary historical catalogue is available dated back to the beginning of the Christian era. The information about the earthquakes in this period has been extracted from ancient Georgian and Armenian annals, as well as from other sources. The parameters of these earthquakes were determined on the basis of the macroseismic data analysis, from contemporary documentary description of damage caused by earthquakes. For the older events errors, in both location and date, may be substantial. The magnitude of largest events were estimated as ~ 6.5-7 and macrosiesmic effect 8-9 on MSK scale (New catalogue…1982). The largest historical events were mainly connected with active faults of the Greater Caucasus (Alaverdi earthquake of 1742, M_s=6.8, I_0=9, Lechkhumi-Svaneti large earthquake of 1350, M_s=7.0, I_0 =9 etc.) and Javakheti plateau in the Lesser Caucasus (Tmogvi earthquake of 1088, M_s=6.5, I_0=9, Akhalkalaki earthquake of 1899, M_s=6.3, I_0 =8-9).

First Seismic Network in Caucasus 1899-1940

The instrumental period of seismology has begun in Georgia in the end of XIX century in 1899 the Tiflis (now Tbilisi) seismic station has been founded in the former Caucasian district of Russian Empire. The horizontal Rebert-Ellert pendulum has been installed on the station. The first seismogram has been recorded 6 December 1899. This gives start to the development of seismology in Caucasus.

Fig. 2 Map of seismic stations installed in Caucasus region in the beginning of XIX c.

After the well-known Shemacha earthquakes, The Permanent Central Commission of Seismicity (PCCS) in Russia founded seven seismic stations in the Caucasus region (***Fig. 2***). The horizontal Omori-Boshi pendulum with mechanical registration was installed in Batumi, Shemaxa, Axalkalaki, Borgomi, Derbent and Zurnabad in 1903–1908. The Bulletins of the PCCS also were published. The following moments of phases were indicated for each earthquakes (mean European time): the beginning of weak oscillations (flicker) of the pendulum T; the beginning of the oscillations C; the beginning of the strong oscillations R; amplification (minimum) of the oscillations M; the end of the oscillation F; and the double-trace amplitude (peak-to-peak) in millimeters A. About 3971 earthquakes had been recorded during this period. Most of them were recorded only at one station. The bad quality of the recording instruments, low velocity of the registration and old identification of the phase could not allow estimation of the earthquakes' parameters. So these instrumental observations did not take very important part in the investigation of the seismicity. (The Earthquakes of the USSR, 1961)

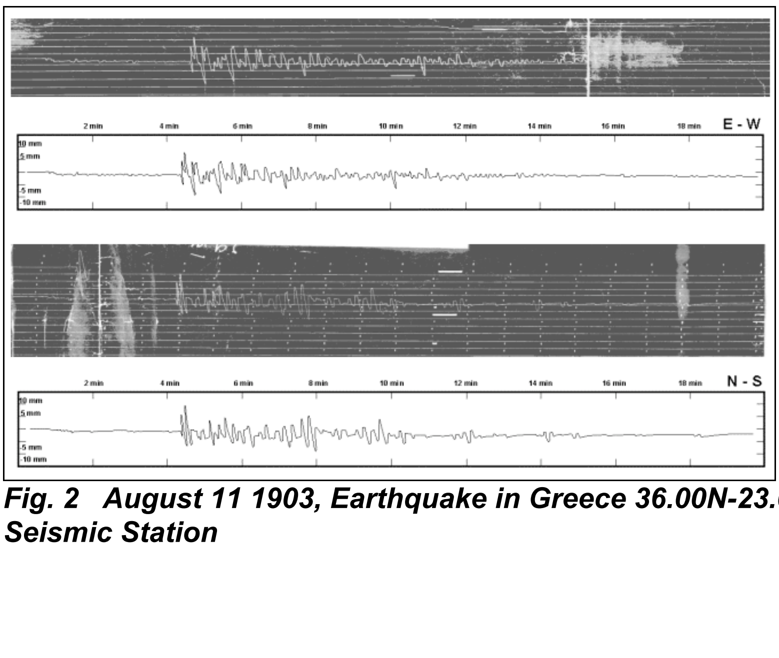

Fig. 2 August 11 1903, Earthquake in Greece 36.00N-23.00E. Recorded in TBILISI Seismic Station

Mainly two types of seismographs were used: horizontal Omori-Bosch seismographs and horizontal Rebert-Ellert pendulum installed in Tbilisi station. Data from these stations deemed to be lost but accidentally appeared in the archive of the Institute of Geophysics, Tbilisi Georgia. At the present work we will concentrate on records from Omori-Bosch horizotal pendulums. Records are maid with the mechanical registration on a smoked paper.

High Sensitive Analogue Seismic Network 1940-2000

In 40-ties the formation of regional network was finished (***Fig. 3***). From the beginning of 1960 network was equipped by high sensitive seismographs of different types. At the end of seventies local seismic networks were established in the region of Enguri Dam (western part of Greater Caucasus) and Javakheti plateau (South Georgia). In eighties about 40 seismic stations were operated in Georgia. During the last years the number of seismic stations has been decreased (from 40 stations in Georgia in 1991 to 10 in 1997) due to political and economical problems. The seismological database of the institute of Geophysics includes the information about 57 000 earthquakes from the whole Caucasus, the data from Georgian, Azerbaijanian and Armenian seismic Networks were collected and proceeded in the Institute of Geophysics (***Fig. 4***).

Fig. 3 Seismic Network of Georgia 1940-2000

In 1998 with the help of Swiss Seismic Survey strong motion network of Georgia has been created. The distribution of seismic and strong motion network is shown on Fig. 1. In accordance with network development, the threshold magnitude has decreased from 4-4.5 in the early instrumental period, to 3.5 in forties, 2.5 since 1960 and less then 2.0 in eighties.

Fig. 4 Distribution of Seismic Stations in Caucasus Region

Due to the transition period, political and economical situation in the country become unstable, which have caused unfortunately destructive results almost in every field of human life. The various circumstances bring the seismic network to reduce the number of stations from 40 to 2. Until 2002 in Georgia permanent working stations were 2. They were quite old in comparing with modern systems operating in the world. According to this we were not able to observe and monitor precisely a seismic activity in the region.

Modern Digital Seismic Network 2002 -

Necessity of modern level seismic monitoring and adequate seismic hazard and risk assessment was once again highlighted by the resent earthquake in Tbilisi. The epicenter of April 25, 2002 earthquake was located within the city limits. Although the earthquake magnitude was 4.5 and intensity up to 7 (MSK scale), there was significant damage in Tbilisi – assessed as 160,000,000 US dollars, 7 people died and several more were injured. This event has once more demonstrated the problems facing us in the field of seismic monitoring, many of which accumulated during the past ten years. Though there were several foreshocks detected a month before the main event it was impossible to monitor the seismic process and make any conclusions due to inadequate monitoring and communications equipment. The precise epicenters were not determined and the same problem appeared concerning mainshock – it was impossible to determine exact location and predict likely damage in the districts of Tbilisi.

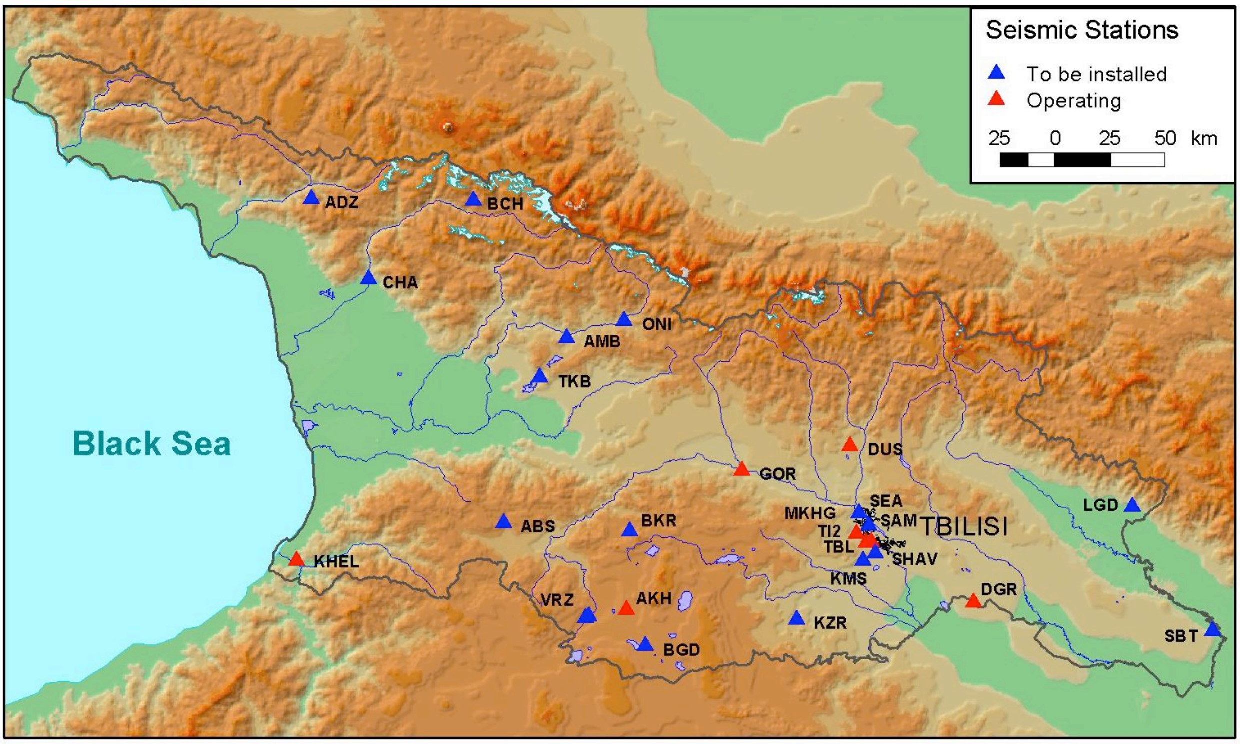

Fig. 5 Modern Digital Seismic Network of Georgia

During the past two years construction of Georgian Seismic Network has started with the help of number of International organizations, Projects and Private companies: Civilian Research and development Foundation (CRDF), NATO Science fro Peace, International Scientific and Technical Center, German Technical Cooperation Agency (GTZ), SZGRF, Bergen University and others. Contributing with seismic equipment. almost each of the seismographs installed are donated by different organizations. At the current moment number of modern digital stations has reached to 7 (***Fig. 5***). The works conducted involved scientific as well as organizational activities: Resolving technical problems concerning communication and data transmission. Due to complicated topography and non-operational telephone lines and power, Dial Up connection, leased telephone lines, or microwave transmission is used depending on local conditions. Providing Power supplies at remote locations using Solar batteries and/or Uninterruptible power supplies, with high capacity batteries.

At the Institute of Geophysics (IG) Special server room with two PC servers, internet connection and uninterruptible plover supply is prepared. At the present period data from Mtatsminda, Delisi and Gori seismic stations is transmitted on online regime to the IG, processed and archived. As far as 7 digital seismic stations are operating at the moment, more attention is drawn to the data processing and database creation. Database is running in Linux platform, special seismic software SHM was selected and the data is recorded in MiniSEED format. All the stations are already integrated into the database. Installation of Linux operating system on PC's and training of appropriate person has started. Catalogue of events recorded is started, already including up to 500 records.

Special attention was drawn to construction of Tbilisi local network (***Fig. 6***). The recent earthquake of 2002 has highlighted the poor seismic resistance of buildings in Tbilisi. Detailed seismic risk assessment must now be done taking into account present conditions of buildings. Unfortunately we should state that after this earthquake Tbilisi has become much more vulnerable. The moderate earthquake located in Tbilisi requires detailed geophysical studies of adjacent area and continuous observations of local seismicity. At the moment two digital stations are operating in Tbilisi and in nearest future it is planned to increase the number up to five.

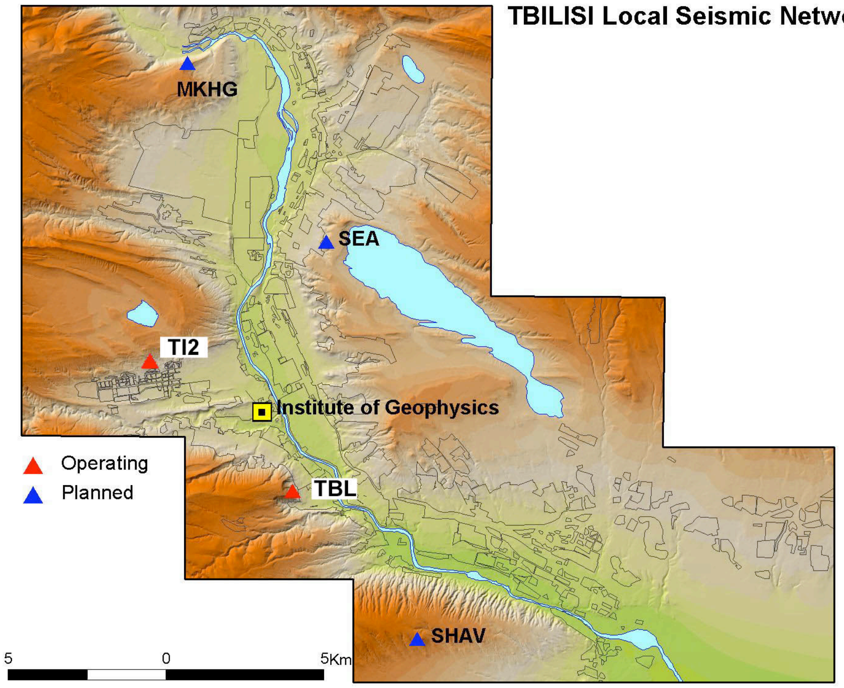

Fig. 6 Near field seismic stations of Tbilisi Local Network

Fig. 7 Mtatsminda (TBL) Geophysical Observatory building and tunnel

As it was mentioned earlier Georgian Seismic Network composes of 7 operating stations:

1. At Mtatsminda Geophysical Observatory (TBL) Guralp 3ESP broadband seismograph is installed (***Fig. 7,8,9***), with GPS time synchronization, digital seismographs is fully functioning, including online data transmission using radio modems. Special devices for extension of data transmission and GPS cables (RS232 cables are limited to max 25-30 m) was designed and assembled. Cables were extended for ~ 150 m, which allow us to install seismograph at the deep (more then 100 m) tunnel.
2. At Delisi Seismic observatory (TI2) was installed Guralp 40T short period seismograph. The equipment is located in 120 m depth tunnel. Dedicated telephone cable connecting Institute of Geophysics and Delisi seismic observatory was installed. Special hardware modems Zelax 115M were tested and has shown wonderful performance. At the moment these two sites are connected with 115 kbps link which is working in continuous regime (having no problems) for about one year already. It should be mentioned that we were not so sure in capability of this kind of connection in the beginning, but now it has shown really good results.
3. Near Black Sea shore Khelvachauri (KHL) seismic station is installed, equipped with Guralp 40T short period sensor coupled with SeisAD 18 public domain digitizer.
4. Gareji (DGR) Seismic station is located to the 50 km South-East of Tbilisi. It is located far from settlements and is equipped with high sensitive (3000 V/m/s) broadband sensor Guralp 3ESP (The same type as at Mtatsminda seismic station) coupled with NetDat data acquisition system with 6 Gb of data storage capacity at site. Special room at the end of 25 m-s depth tunnel was prepared, also special cover for thermal isolation was placed on the sensor.
5. Akhalkalaki (AKH) located in southern part of Georgia – very active Javakheti Valley is equipped with Lennartz LE-3D/5sec sensor coupled with NetDat data acquisition system with 20 Gb of data storage capacity at site.
6. Digital seismic station has been installed in Gori, equipped with Guralp 40T short period seismograph. The station is also operating in online mode using fiber optic cable installed, and the data is available at the central server in the Institute of Geophysics.
7. At Dusheti Seismic station 50 km due to north from Tbilisi was installed Soviet type sensor SM3 and the TURA 24 bit data acquisition unit, designed at our Institute. The unit is designed for local conditions and has a high capacity data storage 30 Gb and is capable for functioning in autonomous regime.

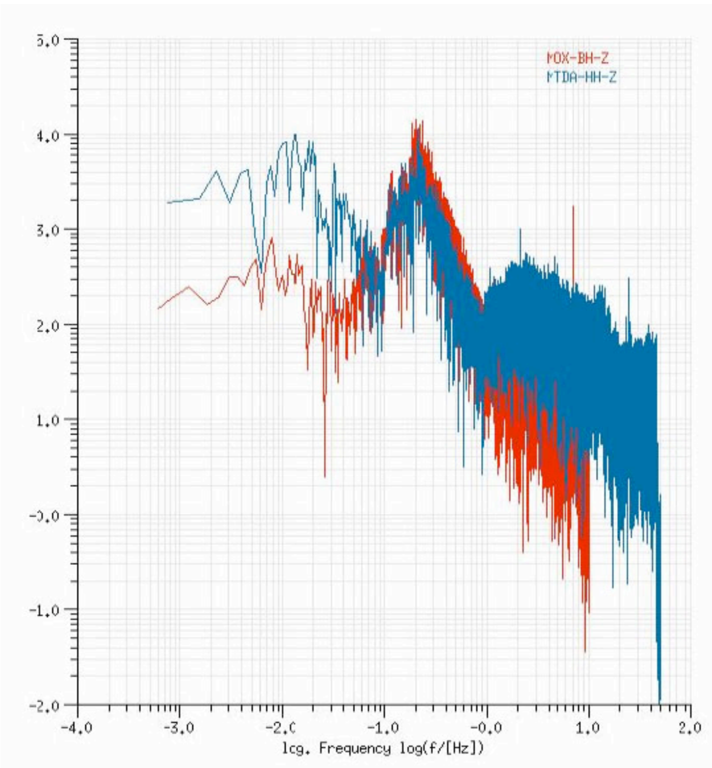

Fig. 8 Mtatsminda (TBL) noise spectra (blue) compared with that of Moxo (MOX) seismic station (red) of German Regional Seismic Network

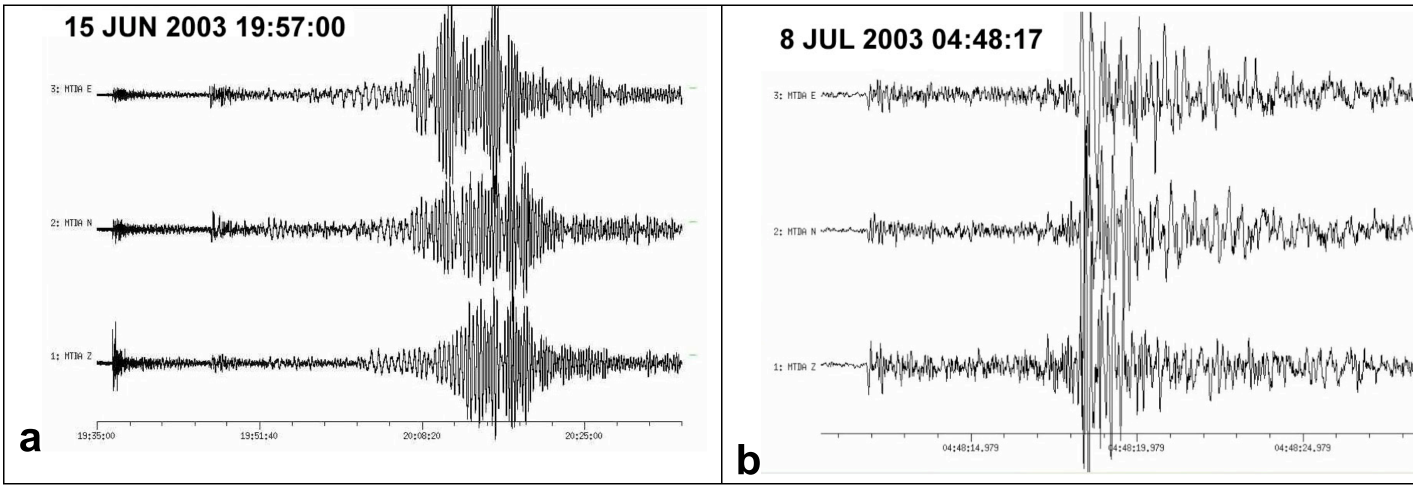

Fig. 9 Records made at Mtatsminda (TBL) seismic station Teleseismic (a) and Local (b)