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Development and Realization of Program for Creation of International Research Center "Geological And Geophysical Testing Ground"

Zaalishvili V.B.
Geophysical Institute – Affiliate of Vladikavkaz Scientific Centre of Russian Academy of Sciences
North Ossetian State University after K.L. Khetagurov
Vladikavkaz, Russia
cgi_ras@mail.ru

Kusraev A.G.
Vladikavkaz Scientific Centre of Russian Academy of Sciences
Vladikavkaz, Russia

***Abstract* – The recent studies demonstrate the activation of geodynamic processes characterized by intense movement of the earth crust, manifestation of newest magmatism and active development of glaciers. The studies of different authors note the migration of seismic phenomena from south to the territory of Caucasus with increasing magnitude by 2025–2030. This is conditioned by the influence of Anatolian and Arabian platforms on the Russian platform. The most seismically active are territories of Dagestan, Chechnya, Ingushetia, Northern Ossetia and Kabardino-Balkaria. The exogenic processes are widely spread in the North Caucasian Federal District. Thus, comprehensive monitoring of volcanic, seismic, glaciological and landslide dangers is high on the agenda together with possible connected catastrophes. It is assumed to identify renewable sources of endogenic energy, the estimation of possible building of ecologically pure geothermal plants and their profitability. The North Caucasus District can be considered as a unique natural laboratory for fundamental science, development of the mineral reserve base and energetics. The creation of the geological and geophysical testing ground will ensure safe life of population and development of the recreational sector.**

Keywords* – *dangerous natural and technogenic processes; monitoring; deep structure; magmatism; seismic danger; glaciers.

I. INTRODUCTION

The main reasons of the technogenic destruction of the ecosystem of North Caucasus District are mining industry and construction of transportation communications [1–3]. The deep structures can be studied by the method of microseismic surveying based on the Rayleigh surface wave [4–9]. Two profiles, Stepnoye–Bakuriani and Volgograd–Nakhichevan, transversely intersecting the structure of the Central Caucasus, were derived by deep seismic sounding [10–11]. Unit profiles of earthquake converted-wave method and gravimagnetic measurements, intersecting the stratovolcanoes Elbrus and Kazbek allow determining the stage of volcano development. The data on Kazbek do not confirm the presence of liquid media, and clear attributes of a volcano are absent in geophysical fields, unlike Elbrus, where such medium is noted by an anomaly in electrical conductivity. Nevertheless, any attempts to divide volcanoes into sleeping and extinct ones without specific studies is quite conditional [12–18].

We assume to study the condition of the massif and estimate the possibility to build a geothermal plant and its profitability [19–20]. All the above conditions the necessity of creation of International Research Center "Geological and geophysical testing ground" in the region which represents a unique natural laboratory for fundamental science, development of mineral reserve base and energetics.

II. SEISMOLOGICAL OBSERVATIONS

Let us note, that among the natural dangers in Caucasus, the most prominently pronounced one is seismicity accompanied by a wide spectrum of secondary processes. In connection with activation of dangerous natural processes and Kolka glacier slide on September 20, 2002 in particular, in 2003 the existing Republic-wide seismic observation network was transformed by the Geophysical Institute into the network of comprehensive observations "Karmadon parametric testing ground" (Fig. 1) [21–27].

According to UN data (Living with risk, 2002), seismic catastrophes amount to 51% of total number of natural cataclysms and dominate among all types of catastrophes [1, 5, 28].

The largest danger for Vladikavkaz and Alagir cities is Vladikavkaz fault with seismic potential of M = 7.1 [29], where a modern instrumental network of seismologic, geodynamic and gravimetric observations is to be created [30].

The glacier catastrophe of 2002 , according to M. Berger is the manifestation of post-volcanic process which had the character of directed explosion-like gas-dynamic discharge [31–42].

The most important condition for correct prognosis of volcanic eruption is comprehensiveness and continuity of observations within each of the methods [43–46].

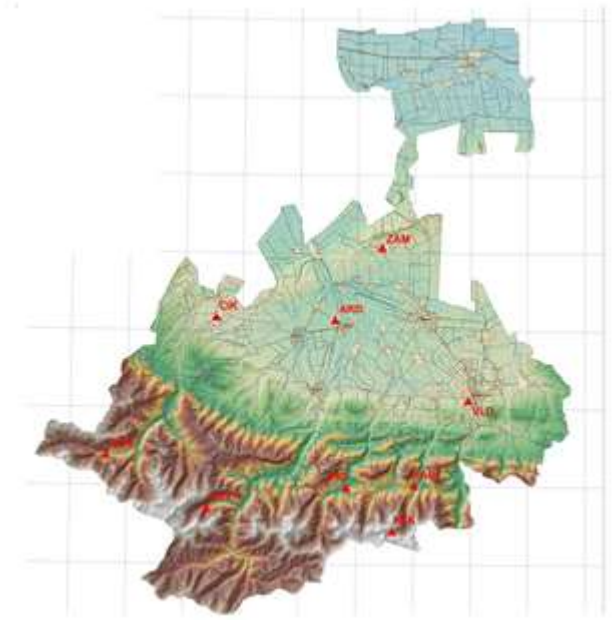

Fig. 1. Network of seismic observations of Karmadon parametric testing ground

In 2012, with the support of Emercom of RF in Republic of North Ossetia-Alania near the Kolka glacier bed, a seismic station was founded (the station code is KLK) at the altitude of 2970 meters above sea level (Figs. 1–2) [47–48].

On May 17, 2014, a heap of ice and rocks slid from the height of 4400–4500 m on the eastern slope of Kazbek near Devdorak glacier. Then, the landslide transformed into an avalanche-like stream or stone-and-ice avalanche [49]. The movement of the stream was detected by the seismic stations of the Karmadon parametric testing ground, located near the transit zone (Fig. 3) [50–52]. The avalanche has blocked Terek river, which conditioned the formation of a choke lake. The danger of the breach posing threat to Vladikavkaz remained until unloading via diversion tunnel of a hydropower plant under construction.

This confirmed the capability of the network to detect geodynamic processes of different nature (landslides, earthfalls, landslips, mudslides, avalanches).

Not less important task was the creation of the seismic monitoring network on urbanized territory, which is urgent for North Caucasus, where such monitoring is virtually absent. During the execution of the international project of NATO program “Science for Peace” on topic “Seismic risk assessment of large cities of Caucasus. Methods of risk management” in 2004 for the first time in North Caucasus in Vladikavkaz, a local network of seismic monitoring at the locations with different ground conditions was organized [53–61].

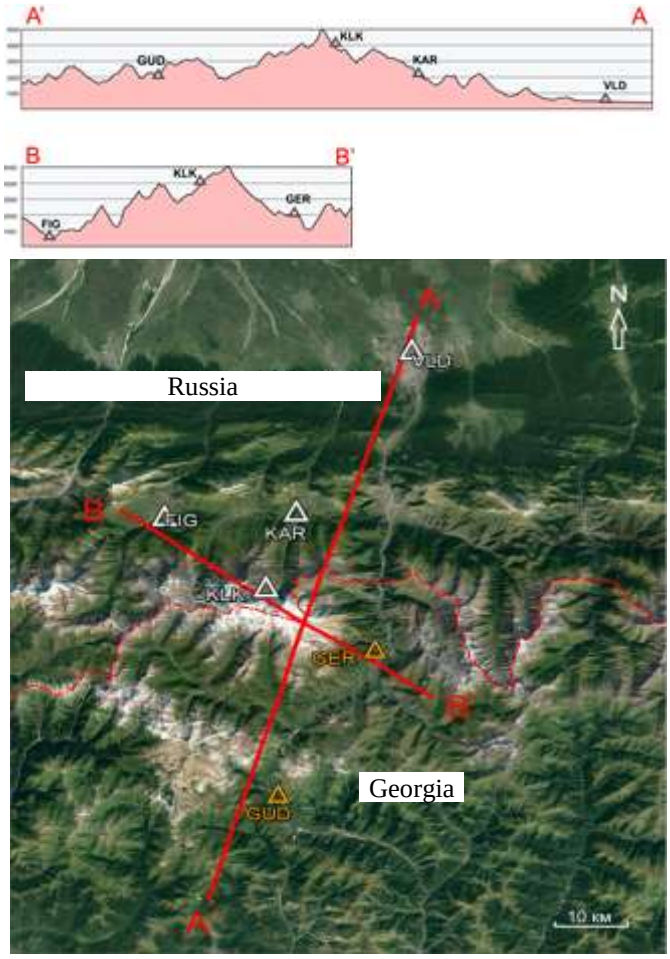

Fig. 2. Location of seismic stations: KLK – Kolka, FIG – Fiagdon, KAR – Karmadon, VLD – Vladikavkaz, GER – Gergeti, GUD – Gudaur

III. GEODYNAMIC NETWORK

North-Caucasus deformation network allows monitoring contemporary movements and deformations of the earth crust [62–65]. North-Ossetian GPS network is practically a part of North-Caucasus geodynamic network that includes GPS sites created within projects of previous epochs.

The first epoch of GPS measurements dates back to 1991 implemented within International project Kavkaz-1991 of IPE AS USSR and the USA.

In 2008, a stationery GPS station “Vladikavkaz” was founded (code VLAD) (Fig. 4). The estimation of current coordinates is carried out by Precise Point Positioning (PPP) included into software package BERNESE 5.0 [66].

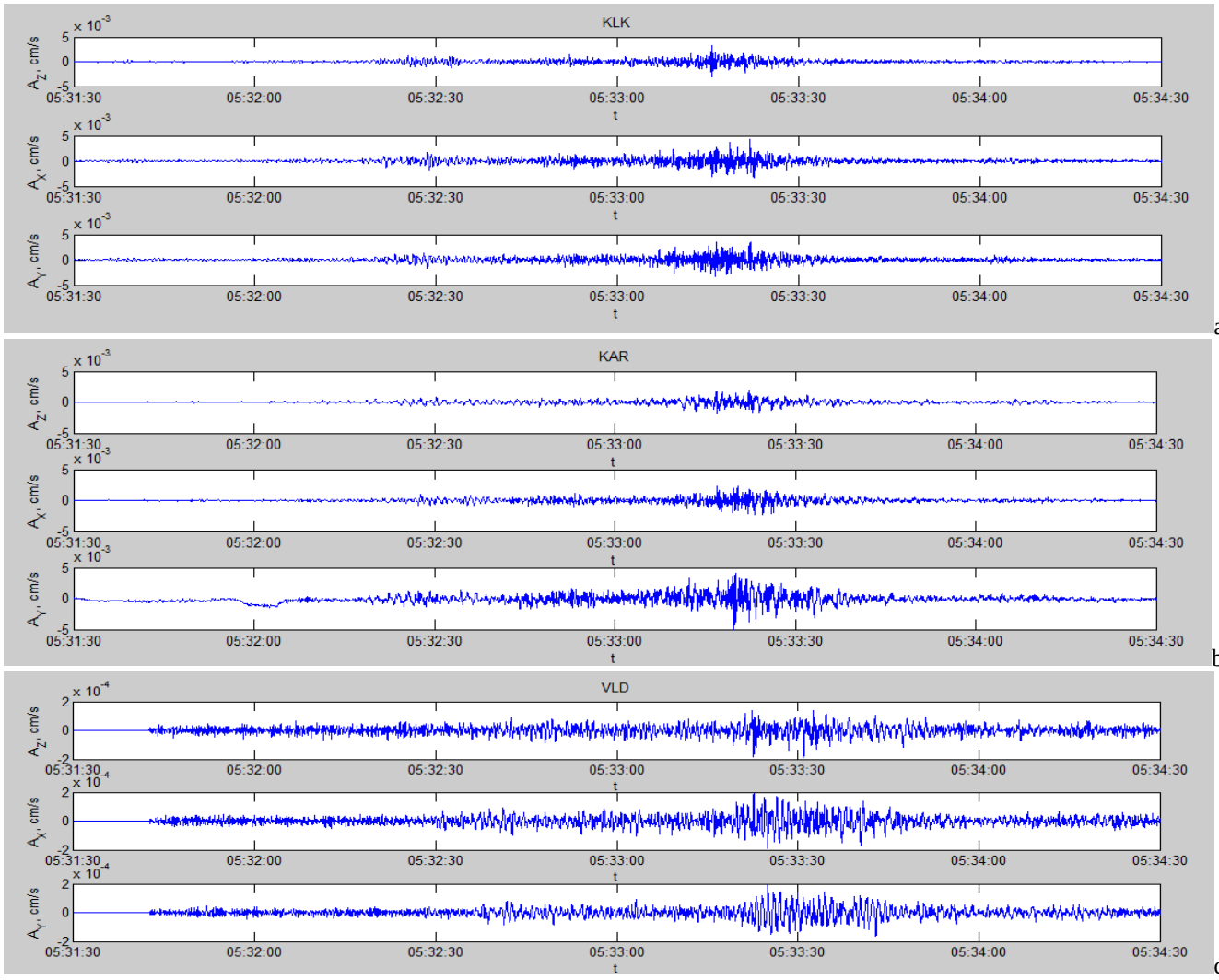

Fig. 3. Seismic records of avalanche-like stream movement on May 17, 2014: a) Kolka (code KLK); b) Karmadon (code KAR); c) Vladikavkaz (code VLD)

The most important geological structures of North Ossetia include Vladikavkaz fault (Fig. 4) identified by geophysical data [67]. The configuration of the fault is interpreted as a subduction of Fore-Caucasus megablock of Scythian epi-Hercynian platform under a crystalline core-area of a mountain structure [67]. This explains the reason for creation of a monitoring system on the fault which potentially will allow forecasting strong earthquakes [63].

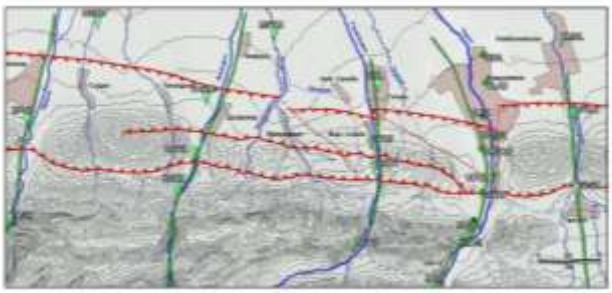

Fig. 4. Location of sites of Vladikavkaz geodynamic forecasting ground in the zone of Vladikavkaz fault zone

The main elements of the system are deformation-geodesy forecasting profiles orthogonally intersecting the seismogenic fault (Fig. 4) [62, 64, 68, 69].

IV. GRAVIMETRIC MEASUREMENTS

The first gravimetric bases on North Caucasus were founded in 1994 within international project SELF (Sea Level Fluctuations). In 1994, in collaboration with experts from IFAG institute (Germany), the absolute values of gravity were measured by FG5 ballistic gravimeter No. 101 in Baksanskaya underground observatory (State Astronomical Institute named after P.K. Steinberg) (Neitrino village, Kabardino-Balkaria) and Zelenchuk branch of the Institute of Applied Astronomy of RAS (Zelenchukskaya stanitsa, Karachaevo-Cherkessia) [70]. Currently, the network of sites for repeated measurements of absolute values of gravity in North-Caucasus region covers the territory of three republics— Karachevo-Cherkessia, Kabardino-Balkaria and North Ossetia—and consists of seven sites: Zelenchukskaya, Neitrino, Azau, Terskol, Nalchik, Vladikavkaz and Ardon [71, 72]. When relative gravimeters Scintrex CG3 and CG5 came to Russia, the errors of relative

measurements became comparable with those of absolute gravimeters. This allowed solving a number of problems of highly accurate gravimetry by less expensive relative gravimeters [71]. The measurements were performed by the researchers from Geophysical Institute and Sternberg Astronomical Institute using relative gravimeter CG5 No. 567 (Scintrex, Canada).

V. SPACE MONITORING

From 2016 on, the institute receives information from Russian Space Systems, JSC. Fig. 5 depicts the Kolka glacier bed made on July 15 (a) and July 18 (b) in 2016. The area of lake no. 1 in the upper part of the zoomed fragment amounts to 1500 m^2, the area of lake no. 2 over the monitoring period increased from 250 m^2 up to 1600 m^2.

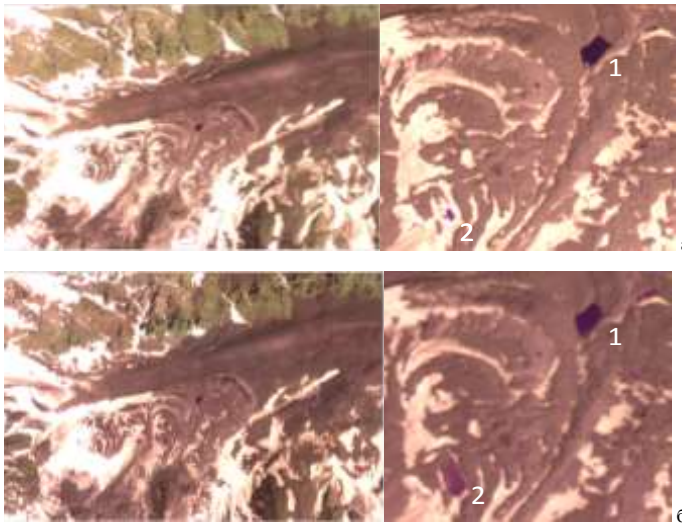

Fig. 5. Space images of Kolka glacier bed on 15.07.2016 (a) and 18.07.2016 (b).

VI. CONCLUSIONS

The creation of instrumental system "Karmadon parametric testing ground", including seismologic, geodynamic and gravimetric monitoring envisages creation of standard scenarios of dangerous geological processes and development of a concept for safety of population in mountain regions.

The seismological monitoring from 2006 is performed by Russian recorders Delta-Geon-2M with GPS time-signal service.

In 2008, in the building of the Geophysical Institute, stationery GPS station Vladikavkaz of regional network for satellite monitoring and gravimetric site Vladikavkaz equipped with Scintrex CG-5 gravimeter were deployed. In 2010, to increase the accuracy of relative gravimetric measurements, a site with measurements of absolute gravity was deployed. In 2012, near Kolka glacier bed (Russia) at the altitude of 2970 meters A.S.L., a seismic station was deployed that on May 17, 2014 detected the descend of mudflows from the southern slope of Kazbek mountain (Georgia) along Devdoraki clove.

Thus, on the territory of Republic of North Ossetia-Alania a modern monitoring system was organized that allows comprehensively solving forecasting problems of dangerous natural and technogenic processes and mitigate different risks.

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