საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 14, №4, 2020
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 14, no. 4, 2020

Geophysics

Seismicity of the Eastern Achara-Trialeti Fold-and-Thrust Belt, Georgia

Aleksandre Gventsadze* **and Nino Kvavadze***

*M. Nodia Institute of Geophysics, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia

(Presented by Academy Member Tamaz Chelidze)

Seismicity of eastern Achara-Trialeti fold-and-thrust belt is presented in the paper. Data of about 400 earthquakes, with Mw≥3.0 were used. It is shown that the distribution of earthquakes, both laterally and vertically, completely coveres eastern Achara-Trialeti fold-and-thrust belt. 2-3D models of earthquake distribution were created. Two main zones can be distinguished for vertical section of earthquake distribution, earthquakes above and below the main detachment. Events above the main detachment are associated with north- and south-vergent thrusts and are concentrated in the backthrusts, forethrusts, and triangle zones. Earthquakes below the main detachment could be related to the re-activation of normal faults in the basement. © *2020 Bull. Georg. Natl. Acad. Sci.*

Lesser Caucasus, Achara-Trialeti fold-and-thrust belt, seismicity

The Achara-Trialeti fold-and-thrust belt (ATFTB) is located in the northern part of the active collisional Lesser Caucasus (LC) orogen (Fig. 1). It is extending from the Black Sea coast towards Tbilisi (360 km along strike and 65-45 km in width). Eastward of Tbilisi it submerges under Neogene Kura molasses [1-3]. Inversion of the Achara-Trialeti extensional basin during late Alpine time is associated with Arabia/Eurasia convergence [4-6].

The present-day geometry of the ATFTB is related to the northward thrusting of the basement wedge and was developed during Miocene [2, 5]. Recent GPS and earthquakes data indicate that the ATFTB is tectonically fairly active [7-9]. Three principal directions of active faults compatible with the dominant near N-S compressional stress produced by the Arabian/ Eurasia convergence have been distinguished in the LC – longitudinal (WNW-ESE or W-E) and two transversal, NE-SW and NW-SE. The first group of structures having the so-called "Caucasian" strike is represented by compressional structures – reverse faults, thrusts, and fault-related folds [7].

Our study is focused on the eastern ATFTB (Figs 1, 2). The main goal of the paper is to analyze the distribution of seismicity, and 3-D visualization of recent earthquakes in the upper crust.

© 2020 Bull. Georg. Natl. Acad. Sci.

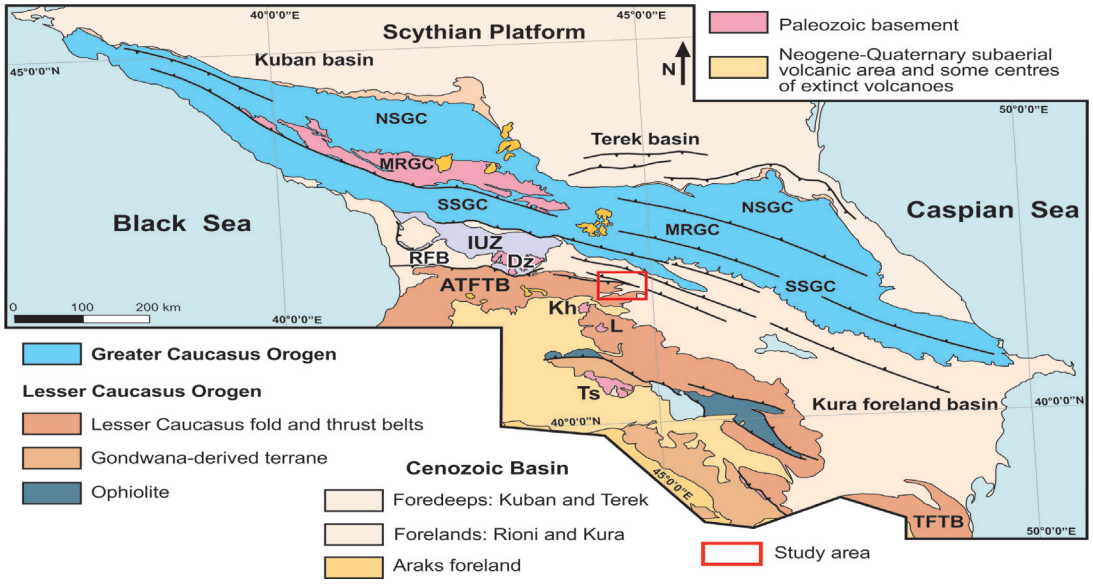

Fig. 1. Simplified tectonic map of the Caucasus [10]. Abbreviations: SSGC- Southern Slope of Greater Caucasus, MRGC-Main Range of Greater Caucasus, NSGC- Northern Slope of Greater Caucasus; RFB-Rioni foreland basin; IUZ-Imereti uplift zone; ATFTB-Achara-Trialeti fold-and-thrust belt; TFTB-Talysh fold-and-thrust belt; DZ-Dzirula; Kh-Khrami; L-Loki; Ts-Tsakhkuniats.

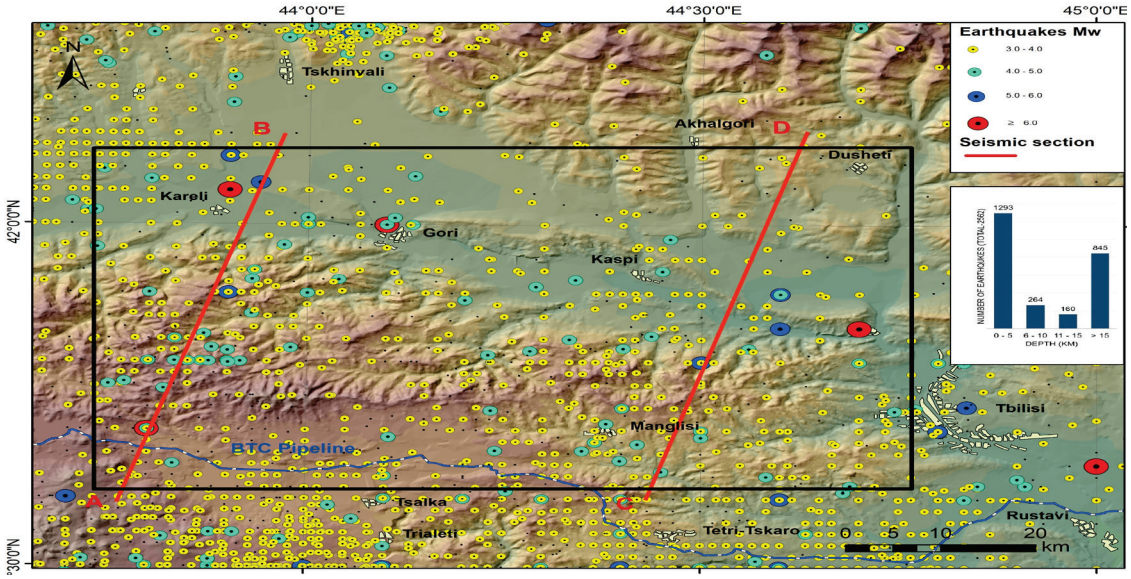

Fig 2. Map of hypocentral distribution of about 400 (Mw≥3.0) selected events of the eastern ATFTB and surrounding area.

The sedimentary cover of the eastern ATFTB is commonly >7 km thick and is represented by Jurassic, Cretaceous, Paleogene and Neogene deep marine, shallow marine and thick continental strata [3, 4, 11]. The structure within the study area is represented by W-E trending folds and north- and south-vergent reverse-faults and thrusts [3, 11]. The eastern ATFTB can be divided into three major structural trends (from south to north): (1) the backthrust zone, (2) the forethrust zone, and (3) triangle zone [5, 12].

Seismic activity of Georgia is confirmed by existing earthquake information. The earthquake catalog used includes both historical (up to 1990) and instrumental (from 1900 to 2016) earthquakes.

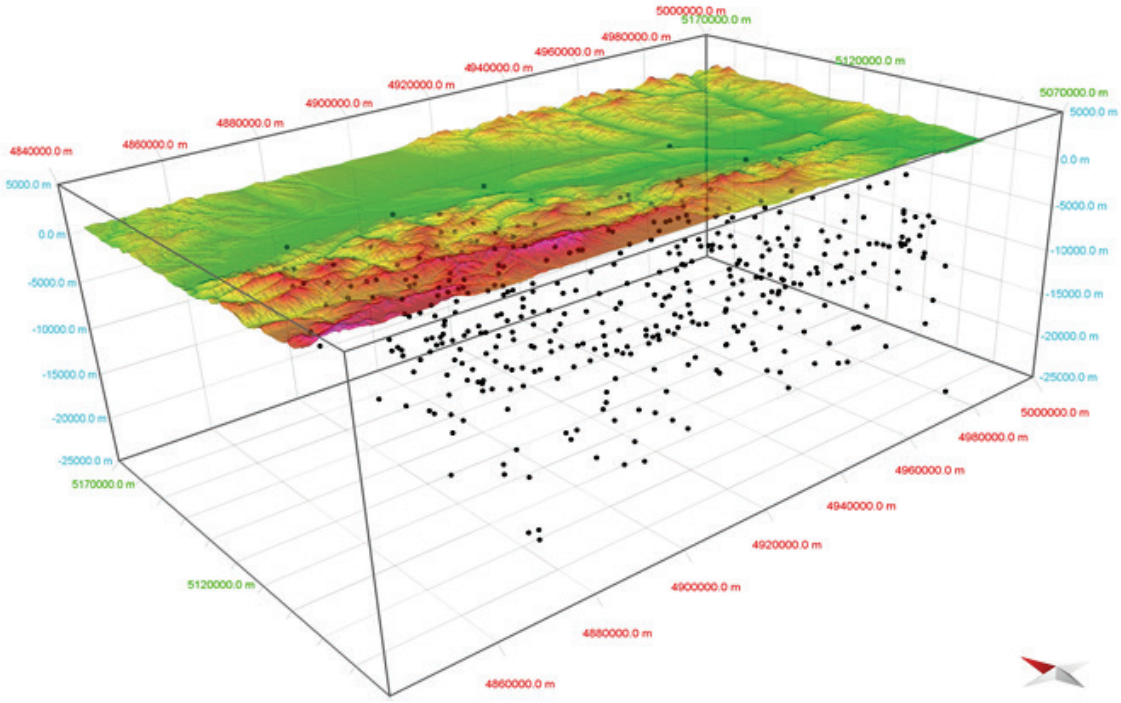

Fig. 3. 3-D visualization of seismicity distribution within the eastern ATFTB (View from West-South).

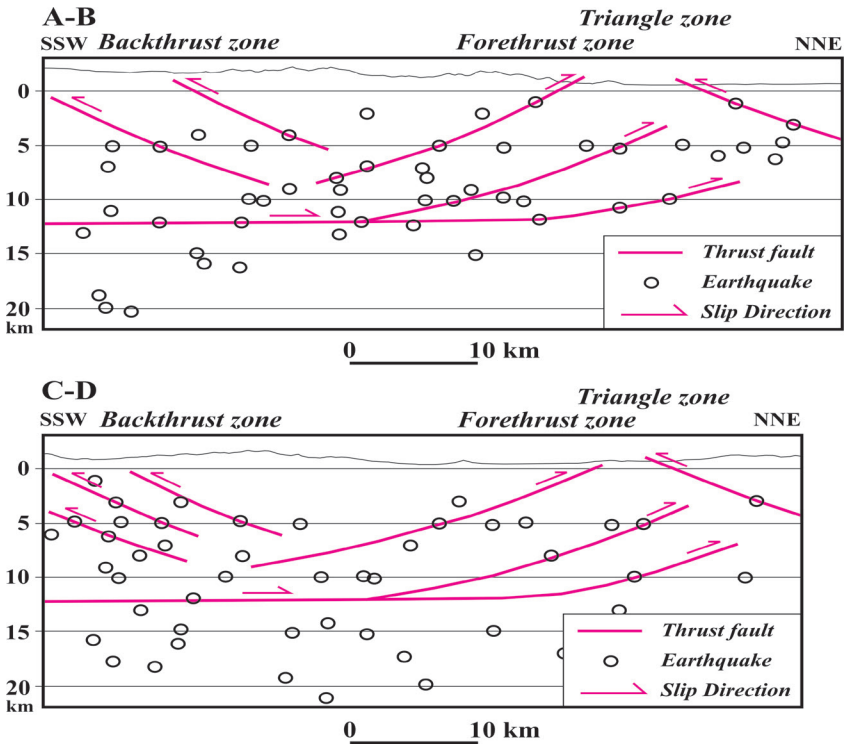

Fig. 4. Vertical sections (A-B, C-D) of seismicity across the eastern ATFTB.

In the study area we have about 400 earthquakes with Mw≥3.0 and depth varying from 1 km to 20 km (Fig. 2). Strongest earthquakes in the area are from historical data. From early instrumental period Gori, 1920 earthquake (Mw=6.2), was the most destructive [13]. Within study area 3-D model of earthquakes distribution (Fig. 3) and two (A-B, C-D), 2-D vertical sections (Fig. 4) were constructed. 3-D model of earthquakes distribution was constructed using move software. 3-D visualization of earthquake propagation and vertical profiles (A-B, C-D) show that their lateral and vertical propagation completely includes the eastern ATFTB (Figs 3, 4).

On the vertical sections of earthquake distribution (A-B, C-D) two main zones can be distinguished, earthquakes above and below the main detachment (Fig. 4). Main detachment is located between Mesozoic strata and Paleozoic basement. Events above the main detachment are associated with north- and south-vergent thrusts and are concentrated in the backthrusts, forethrusts, and triangle zones. Earthquakes below the main detachment could be related to the re-activation of normal faults in the basement (Fig. 4). It should be noted, that most of the earthquakes focal mechanisms within the study area are associated with thrusts and reverse faults [9, 14].

Seismic occurrence below the main detachment suggests that the pre-existing structure, developed during the Upper Miocene-Pleistocene [2,5] compressive deformation, controls the thickness of the seismogenic layer and the thick-skinned tectonics.

The work was supported by Shota Rustaveli National Science Foundation of Georgia, SRNSF #PHDF-18-1039 – Structural architecture of active back-thrust zone of the eastern Achara-Trialeti fold-and-thrust belt (Kumisi-Teleti area), Georgia.

გეოფიზიკა

აღმოსავლეთ აჭარა-თრიალეთის ნაოჭა-შეცოცებითი სარტყლის სეისმურობა, საქართველო

ა. გვენცაძე* და ნ. ყვავაძე*

*ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, მ. ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი, საქართველო

(წარმოდგენილია აკადემიის წევრის თ. ჭელიძის მიერ)

სტატიაში წარმოდგენილია აღმოსავლეთ-აჭარა-თრიალეთის ნაოჭა-შეცოცებითი სარტყლის სეისმურობა. გამოყენებულია დაახლოებით 400 მიწისძვრის მონაცემები, მაგნიტუდით Mw≥3,0. ნაჩვენებია, რომ მიწისძვრების გავრცელება, როგორც ლატერალური, ასევე ვერტიკალური მიმართულებით მთლიანად მოიცავს აღმოსავლეთ აჭარა-თრიალეთის ნაოჭა-შეცოცებით სარტყელს. აგებულია მიწისძვრების გავრცელების 2- და 3-განზომილებიანი მოდელები. გამოთქმულია მოსაზ-

რება, რომ მიწისძვრების გავრცელების ვერტიკალურ ჭრილში შეიძლება გამოიყოს ორი, ძირითადი მოწყვეტის ზევით და ქვევით განვითარებული ზონები. ძირითადი მოწყვეტის ზევით გავრცელებული მიწისძვრების ფორმირება დაკავშირებულია სამხრეთ- და ჩრდილო-ვერგენტულ შეცოცებებთან, ხოლო ძირითადი მოწყვეტის ქვევით გავრცელებული მიწისძვრები დაკავშირებული უნდა იყოს ფუნდამენტში არსებული ჭიმვითი რღვევების რეაქტივიზაციასთან.

REFERENCES

1. Adamia Sh., Gamkrelidze I., Zakariadze G., Lordkipanidze M. (1974) Achara-Trialeti trough and problem of origin of the deep marine trough of the Black Sea. *Geotectonics,* 1: 78-94.
2. Banks C. J., Robinson A. G., Williams M. P. (1997) Structure and regional tectonics of the Achara-Trialeti fold-belt and the adjacent Rioni and Karli foreland basins, Republic of Georgia. *Regional and Petroleum Geology of the Black Sea and Surrounding Region,* 331–346.
3. Gamkrelidze I. (1976) Mekhanism formirovania tektonicheskikh struktur i nekotorye voprosy tektonogeneza, 1-226 Tbilisi (in Russian).
4. Adamia Sh., Alania V., Ananiashvili G., Bombolakis E., Chichua G., Girshiashvili D., Martin R., Tatarashvili L. (2002) Late Mesozoic-Cenozoic geodynamic evolution of the eastern Georgian oil-gas bearing basins. *Geologica Carpathica,* 53: 155-159.
5. Alania V., Chabukiani A., Chagelishvili R., Enukidze O., Gogrichiani K., Razmadze A., Tsereteli N. (2017) Growth structures, piggyback basins and growth strata of Georgian part of Kura foreland fold and thrust belt: implication for Late Alpine kinematic evolution. *Geological Society, London, Special Publications,* 428: 171-185.
6. Sosson M., Stephenson S., Sheremet Y., Rolland Y., Adamia Sh., Melkonian R., Kangarli T., Yegorova T., et al. (2016) The Eastern Black Sea-Caucasus region during Cretaceous: new evidence to constrain its tectonic evolution. *Compte-Rendus Geosciences,* 348: 23-32.
7. Adamia Sh., Alania V., Chabukiani A., Kuloshvili S., Maisuradze G., Gotsiridze, G. (2004) Seismic source zone models of recent earthquakes of Georgia. *Proceedings of the 5th International Symposium on Eastern Mediterranean Geology,* 545–551, (Thessaloniki, Greece)
8. Sokhadze G., Floyd M., Godoladze T., King R., Cowgill E. S., Javakhishvili Z., Hahubia G., Reilinger R. (2018) Active convergence between the Lesser and Greater Caucasus in Georgia: Constraints on the tectonic evolution of the Lesser–Greater Caucasus continental collision. *Earth and Planetary Science Letters,* 481: 154–161.
9. Tsereteli N., Tibaldi A., Alania V., Gventsadse A., Enukidze O., Varazanashvili O., Müller B. I. R. (2016) Active tectonics of central-western Caucasus, Georgia. *Tectonophysics,* 691: 328–344.
10. Alania V., Enukidze O., Giorgadze A., Glonti N., Glonti B., Koiava K., Razmadze A. et al. (2018) Structural architecture of the Kura foreland fold-and-thrust belt using seismic reflection profile, Georgia. *Universal Journal of Geoscience,* 6: 184-190.
11. Papava D. (1967) Voprosy geologii vostochnoi chasti Trialetskogo khrebta i perspektivy neftegazonosnosti melovykh i paleogenovykh otlozhenii, 188-204. Leningrad (in Russian).
12. Alania V., Beridze T., Enukidze O., Lebanidze Z., Razmadze A., Sadradze N., Tevzadze N. (2020) Structural Model of the Frontal Part of the Eastern Achara-Trialeti Fold-and-Thrust Belt: The Results of Seismic Profile Interpretation. *Bull. Georg. Nat. Acad. Sci.,* 14 (2): 62-68.
13. Varazanashvili O., Tsereteli N., Tsereteli E. (2011) Historical earthquakes in Georgia (up to 1900): source analysis and catalogue compilation, 1-81 Pub. Hause MVP, Tbilisi.
14. Adamia S., Alania V., Tsereteli N., Varazanashvili O., Sadradze N., Lursmanashvili N., Gventsadze A. (2017) Postcollisional tectonics and seismicity of Georgia. *Geological Society of America Special Papers* 525: SPE525-17.

Received July, 2020