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Geophysics

Seismic Interpretation of Southern Part of the Eastern Achara-Trialeti Fold-and-Thrust Belt, Georgia

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(Presented by Academy Member Tamaz Chelidze)

In this paper, we present a seismic interpretation of the southern part of the eastern Achara-Trialeti fold-and-thrust belt. Fault-related folding and wedge thrust folding theories were used to constrain the seismic interpretation. The interpreted seismic profile has revealed that compressional structures are represented by shallow south-vergent fault-related folds, south-vergent thrusts and north-vergent duplexes. Tsveri anticline on the seismic profile is characterized by thick asymmetrical anticlinal core and its formation is related to extensional regime and showing typical inversion geometry in an inverted half-graben. The structural style of deformation within the southern part of the eastern Achara-Trialeti fold-and-thrust belt is a series of fault-propagation folds. The kinematic evolution of the south-vergent fault-propagation folds is related to the northward propagating structural wedges. *© 2021 Bull. Georg. Natl. Acad. Sci.*

Achara-Trialeti fold-and-thrust belt, seismic reflection profile, fault-propagation fold, duplex

The Achara-Trialeti fold-and-thrust belt (ATFTB) is located in the northern part of the active collisional Lesser Caucasus orogen (Fig. 1). It extends from the Black Sea coast towards Tbilisi (360 k m along strike and 65-45 km in width). The eastern ATFTB plunges east in the area south of Tbilisi, and continues plunging into the eastern part of the Kura Basin [1]. The ATFTB is the result of the structural inversion of a back-arc rift basin, the likely eastward prolongation of the Eastern Black Sea, and opened in Cretaceous-Eocene times [2-4]. Inversion of the Achara-Trialeti extensional basin during late Alpine time is associated with Arabia/Eurasia convergence [3-6]. The present-day geometry of the ATFTB is related to the northward thrusting of the basement wedge and was developed during Miocene [3, 6].

Despite a long history of the geological study of the eastern ATFTB, certain structural and tectonic issues still remain controversial. One of the main problems is the structural architecture and kinematics of south-vergent fault-related folds. Several structural models of the eastern ATFTB have been proposed in the literature. These published models have been constrained by surface geological data [7-10].

Our study is focused on the southern part of the eastern ATFTB (Figs 1, 2) aiming to define the geometry of shallow fault-related folds and deformation structural style. This paper presents a new model of the compressional structures developed in the southern part of the eastern ATFTB based on the interpretation and analysis of the surface geology and seismic reflection profile. Seismic interpretation presented here is constrained by surface geology. Fault-related folding and

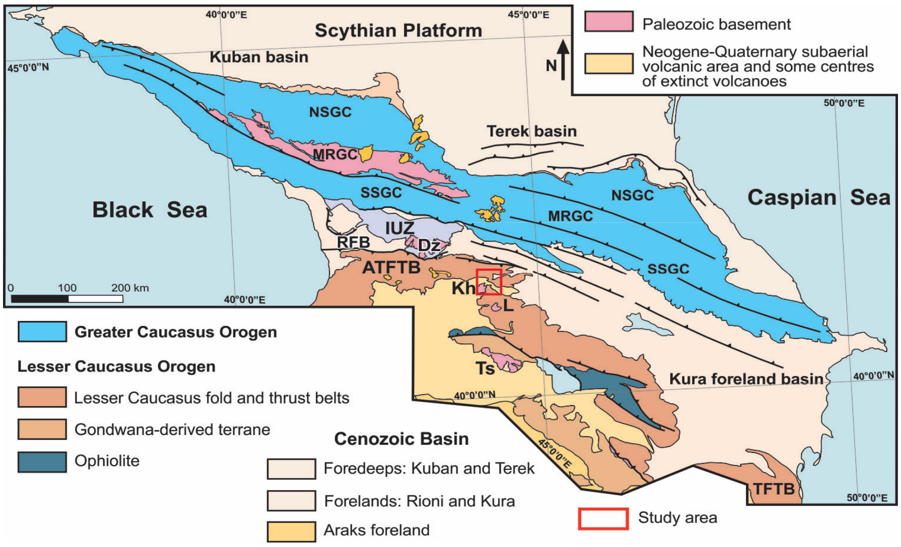

Fig. 1. Simplified tectonic map of the Caucasus [11]. Abbreviations: SSGC- Southern Slope of Greater Caucasus, MRGC-Main Range of Greater Caucasus, NSGC- Northern Slope of Greater Caucasus; RFB-Rioni foreland basin; IUZ-Imereti uplift zone; ATFTB-Achara-Trialeti fold-and-thrust belt; TFTB-Talysh fold-and-thrust belt; DZ-Dzirula; Kh-Khrami; L-Loki; Ts-Tsakhkuniats.

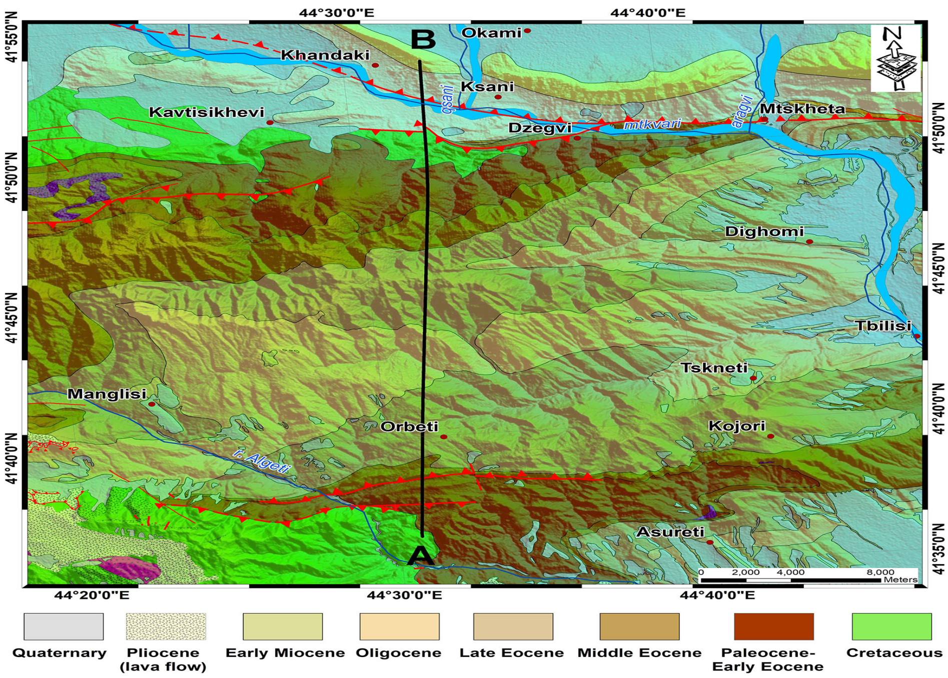

Fig. 2. Geological map of the study area, modified from D. Papava [9].

wedge thrust folding theories were used to constrain the seismic interpretation [12-14].

The stratigraphic relationships in the eastern Achara-Trialeti are complicated by tectonic phases in the Cretaceous-Cenozoic [1, 6]. The sedimentary cover of the eastern ATFTB is commonly>6 km thick and is represented by Jurassic, Cretaceous, Paleogene and Neogene deep marine, shallow marine and thick continental strata [1, 4]. During Cretaceous and Paleogene, the Achara-Trialeti extensional basin was filled with approximately 3500-4000 m of sediments [1].

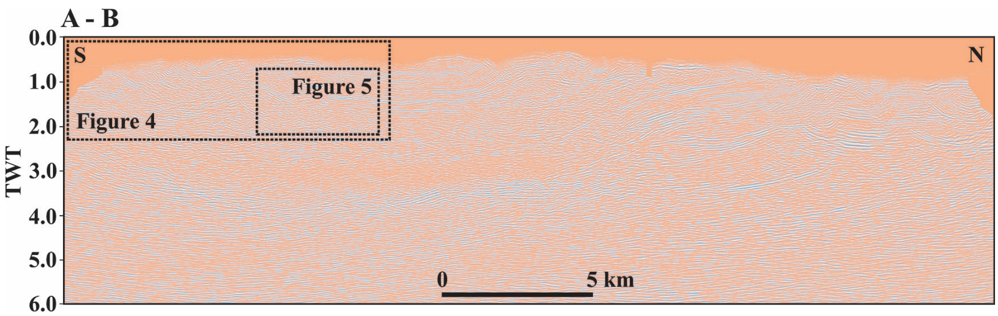

Fig. 3. Seismic reflection profile A-B. Location is shown in Fig. 2.

The general structure of the eastern ATFTB was described by V. Belousov [8], P. Gamkrelidze [7], I. Gamkrelidze [10], D. Papava [9], and others. The structure within the study area (Fig. 2) is represented by W-E trending folds and north- and south-vergent reverse-faults and thrusts [7-10]. 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 [15, 16]. The major structural trends are formed by fault-bend, fault-propagation folds and duplex that transfer shortening from the mountain belt towards the north into the Kura foreland basin [15, 16]. New low-temperature thermochronological data (fission-track and (U-Th)/He analyses on apatite) show that the Achara-Trialeti back-arc basin was inverted and developed as a fold-and-thrust belt starting at 14-10 Ma, in tune with widespread Middle-to-Late Miocene shortening and exhumation, from the eastern Pontides of north-eastern Turkey to the Lesser Caucasus in northern Armenia and north-western Azerbaijan, to the Talysh and Alborz ranges of northern Iran. Such a supraregional tectonism can be interpreted as a far-field effect of the Arabia-Eurasia collision along the Bitlis suture up to 400 km to the south [17]. Recent earthquakes data indicate that the eastern ATFTB is tectonically moderately active [18, 19].

To illustrate the structural model of the southern part of the eastern ATFTB we present the new interpreted time migrated seismic image along the profile A-B (Figs. 3, 4). The location of the seismic reflection profile is shown in Fig. 2. For the interpretation of the seismic profile, we used surface geological information obtained from 1:50.000 scale geological map [9] and our personal field data (Fig. 2). Seismic reflection data in the southern part of eastern ATFTB have revealed presence of passive-roof duplexes in Cretaceous-Paleogene rocks. The tops and bottoms of the duplexes are defined by backthrusts and sole thrusts, which follow bedding planes within Cretaceous-Paleogene strata (Fig. 4). Above the duplex (or structural wedge) are developed south-vergent Tsveri and Kveseti anticlines. The main style of deformation within the backthrust zone is a series of fault-propagation folds which are composed by Cretaceous-Paleogene strata. The kinematic evolution of the south-vergent backthrust zone is related to the

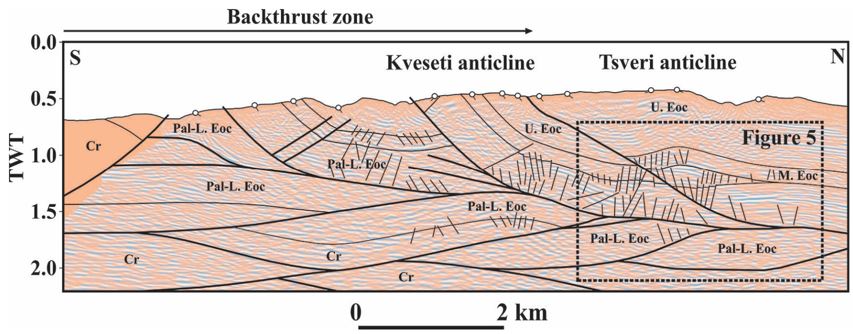

Fig. 4. Interpreted seismic reflection profile A-B (fragment). Location is shown in Fig. 2. Abbreviations: Cr –Cretaceous; Pal-L. Eoc – Paleocene-Lower Eocene; M. Eoc – Middle Eocene; U. Eoc – U. Eocene.

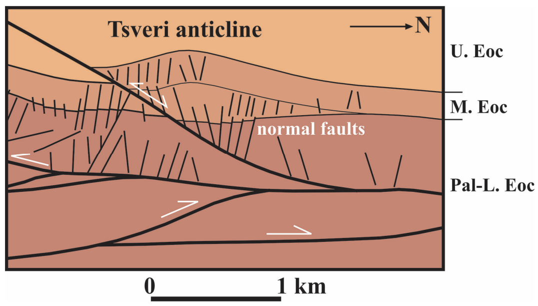

Fig. 5. Seismo-geological cross-section of the Tsveri anticline. Abbreviations: Pal-L. Eoc – Paleocene-Lower Eocene; M. Eoc – Middle Eocene; U. Eoc – U. Eocene.

northward propagating structural wedge (or duplexes). Seismic reflection data interpretation shows that the area was affected at least by two main deformational phases, which caused firstly the formation of extensional structures (normal faults) and then compressional structures (duplexes, south-vergent fault-related folds backthrusts) (Figs. 4, 5).

The inversion structure (Tsveri anticline) on the seismic profile is characterized by thick asymmetrical anticlinal cores representing the extensional regime and showing typical inversion geometry in an inverted half-graben [20] (Fig. 5).

Determining the geometry of shallow Tsveri and Kveseti fault-propagation folds and wedge (or duplex) structure in the southern part of the eastern ATFTB is a helpful tool for understanding the geometry and deformation structural style of the study area.

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გეოფიზიკა

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სტატიაში წარმოდგენილია აღმოსავლეთ აჭარა-თრიალეთის ნაოჭა-შეცოცებითი სარტყლის სეისმური ინტერპრეტაცია. რღვევებთან დაკავშირებული ნაოჭების და შეცოცებითი სოლების თეორიის გამოყენებით ჩატარდა სეისმური პროფილის ინტერპრეტაცია. ინტერპრეტირებული სეისმური პროფილი გვიჩვენებს, რომ კუმშვითი სტრუქტურები წარმოდგენილია ზედაპირული სამხრეთ-ვერგენტულ რღვევებთან დაკავშირებული ნაოჭებით, სამხრეთ-ვერგენტული შეცოცებებით და ჩრდილო-ვერგენტული დუპლექსებით. წვერის ანტიკლინი სეისმურ პროფილზე ხასიათდება სქელი ასიმეტრიული ანტიკლინის გულით, რომლის ფორმირება დაკავშირებულია ჭიმვით რეჟიმთან და გვიჩვენებს ტიპურ ნახევრად გრაბენული სტრუქტურის ინვერსიის გეომეტრიას. აღმოსავლეთ აჭარა-თრიალეთის ნაოჭა-შეცოცებითი სარტყლის სამხრეთ ნაწილის დეფორმაციის სტრუქტურული სტილი წარმოდგენილია რღვევა-გავრცელებადი ნაოჭების სერიით. სამხრეთ-ვერგენტული რღვევა-გავრცელებადი ნაოჭების კინემატიკური ევოლუცია დაკავშირებულია ჩრდილოეთის მიმართულებით გადაადგილებულ სტრუქტურულ სოლებთან.

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