Geophysics

Thrust-Related Basin within Two-Orogen Convergence Zone in the Western Kura Basin

Victor Alania*, Onise Enukidze*, Nino Kvavadze*, Alexander Razmadze, Tamar Beridze**, Mariam Bekurashvili§, Tamar Shikhashvili***

** I. Nodia Institute of Geophysics, Ivane Javakhishvili Tbilisi State University, Georgia*
*** A. Janelidze Institute of Geology, Ivane Javakhishvili Tbilisi State University, Georgia*
§ Faculty of Mining Geology and Sustainable Mountain Development, Georgian Technical University, Tbilisi, Georgia

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Abstract. This study focuses on the geometry and kinematics of Late Miocene growth strata developed in the western Kura foreland basin, located within the convergence zone of the Lesser Caucasus and Greater Caucasus orogens, using seismic profiles. Based on seismic profiles and surface geological data, a fault-related basin was identified in the western Kura foreland basin and termed the Mukhrani–Saguramo fault-related basin. The structural evolution of the Mukhrani–Saguramo fault-related basin was controlled by the frontal parts of the Lesser Caucasus orogen to the south and the Greater Caucasus orogen to the north. Seismic data reveal two stages in the kinematic evolution of the Late Miocene growth strata. The first stage is dominated by passive back-thrusting, while the second stage involves both wedge thrusting and passive back-thrusting. *© 2026 Bull. Natl. Acad. Sci. Georg.*

Keywords: two orogens convergence zone, western Kura foreland basin, seismic reflection profile, thrust-related basin, growth strata

Introduction

Extensive intracontinental deformation in the far-field zone of the collision of Arabia-Eurasian plates during the Late Alpine period formed two orogens, leading to a convergence between the Lesser Caucasus (LC) and Greater Caucasus (GC) (Alania et al., 2023, 2025; Cavazza et al., 2024; Corrado et al., 2021; Nemcok et al., 2013). Continuous convergence between the LC and GC caused incremental deformation of the Rioni and Kura foreland basins (Adamia et al., 2010; Alania et al., 2017, 2021, 2022; Banks et al., 1997; Gusmeo et al., 2021, 2022; Sokhadze et al., 2018; Tari et al., 2021).

Our study area (Fig. 1) is located within the LC-GC convergence zone in the western Kura foreland basin (KFB) and is represented by the lenticular-shaped compressional basin formed by northward and southward-directed thrusting. This basin, named by us as the Mukhrani-Saguramo thrust-related basin (MSTRB), is an asymmetric structure covering a surface area of approximately 260 km2 (Fig. 1). The Late Miocene strata units within the MSTRB preserve important information for understanding the tectonic processes of convergence between the LC and GC. In this paper, we focus on the geometry of the Late Miocene growth strata within this thrust-related basin developed between the LC-GC orogens' convergence zone in the western KFB using seismic reflection profiles. We also discuss the timing and kinematics of the late Cenozoic deformations.

Geological setting. In the study area (Fig. 1), the convergence zone of two orogens is introduced by the frontal parts of the LC retro-wedge and the GC pro-wedge (Alania et al., 2023) (Fig. 2). The frontal part of the LC retro-wedge is represented by a triangle zone (Alania et al., 2017, 2020). The

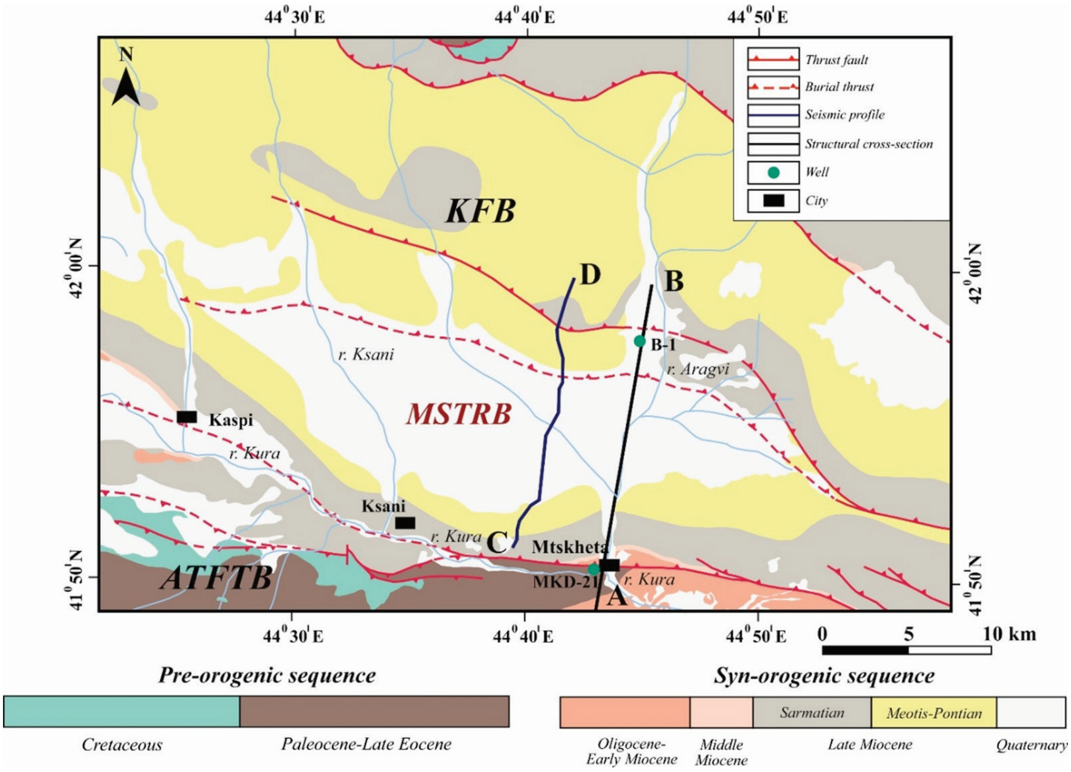

Fig. 1. Geological map of the western KFFTB and surrounding area (Alania et al., 2023). Abbreviations: ATFTB-Ajara-Trialeti fold-and-thrust belt; KFB-Kura foreland basin; MSTRB-Mukhrani-Saguramo thrust-related basin.

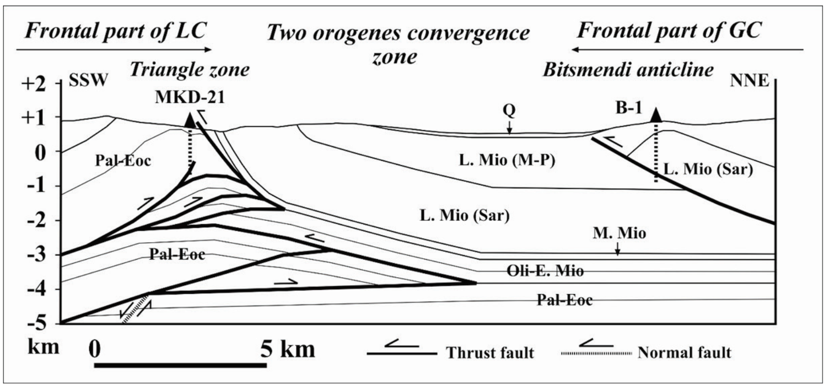

Fig. 2. Structural cross-section A-B across LC-GC convergence zone (Alania et al., 2023). Abbreviations: Pal-Eoc – Paleocene-Eocene; Oli-E. Mio – Oligocene-Early Miocene; M. Mio-Middle Miocene; L. Mio (Sar) – Late Miocene (Sarmatian); L. Mio (M-P) – Late Miocene (Meotis-Pontian); Q-Quaternary.

Bitsmendi anticline was formed due to the movement along the frontal fault of the GC and shows significant along-strike variations in structural geometry. East-West directed along-strike structural variation of the frontal thrust is observed on the interpreted seismic profiles, which affected the fold geometry. The Bitsmendi breakthrough fault-propagation fold gradually transits into a breakthrough wedge structure in the W-E direction and is represented by the typical wedge structure in its extreme termination (Alania et al., 2023). In the top view, the maximum convergence of the frontal parts of two orogens occurs at both ends of the lenticular-shaped MSTTB (Fig. 1).

The western KFB sedimentary infill (thickness more than 6 km) consists of pre-and syn-orogenic sequences (Alania et al., 2017, 2021, 2023). The pre-orogenic sequences consist of Jurassic-Late Eocene shallow and deep marine deposits (Adamia et al., 2002, 2010; Tari et al., 2021). The syn-orogenic sequences are composed of the foreland basin (Oligocene-Early Miocene) and syn-tectonic strata (Middle-Late Miocene - Pliocene) with dominance of siliciclastic sequences (Alania et al., 2023). Syn-tectonic strata are represented by shallow marine and continental sediments (Adamia et al., 2002, 2010; Alania et al., 2017).

Recent GPS, earthquakes, and paleoseismic data indicate that the western KFB is tectonically fairly active (Adamia et al., 2004; Sokhadze et al., 2018; Stahl et al., 2022; Tibaldi et al., 2020; Tsereteli et al., 2016).

Data and Method

The surface geological information was obtained from the 1:100,000-scale geological map (Alania et al., 2023) of the study area (Fig. 1). To constrain the geometry of the growth strata in the western KFB, we used four post-stack depth-migrated 2D seismic profile (Fig. 3). The seismic profile C-D is oriented nearly perpendicular to the dominant structural trends of the western KFB. Fault-related folding and wedge thrust folding theories (Shaw et al., 2005) were used in the interpretation of the 2D seismic reflection profile.

Results and Discussion

In this study, we define the geometry and kinematic evolution of the MSTRB growth strata. Based on the 2D seismic profile (Fig. 3) and field outcrop

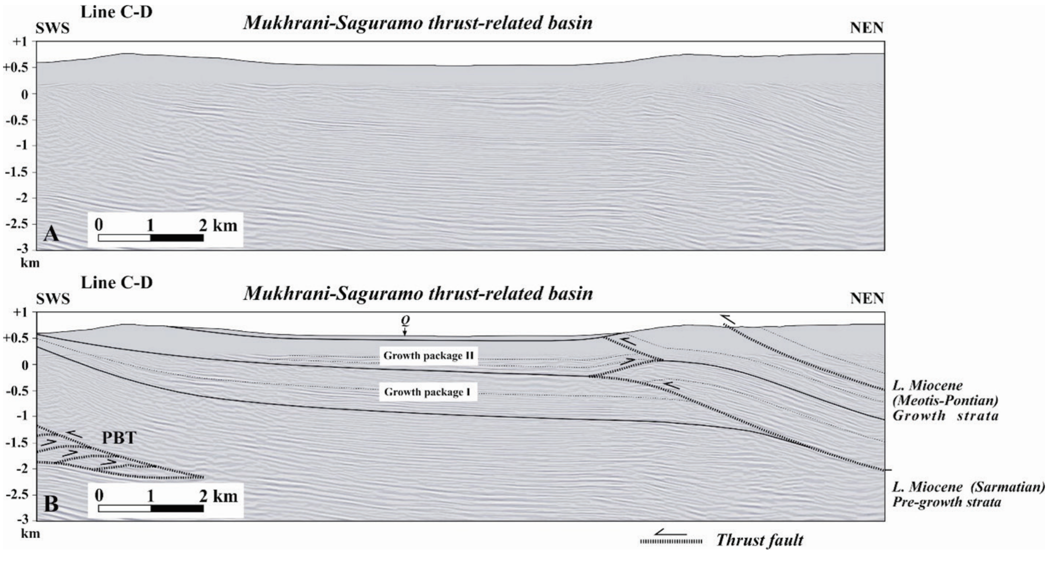

Fig. 3. (A) Uninterpreted line-drawing seismic profile C-D. (B, C) Interpreted line-drawing of seismic profile (C-D). The seismic reflection profile displays two Late Miocene growth packages (I and II). Varying geometries, seismic reflections, and depocenters characterize the growth sequence architecture.

data, we have established the geometry of the MSTRB since the ~7Ma (Meotian-Pontian – Late Miocene). The MSTRB is composed of c. 2.5 km thick growth strata, including Late Miocene (Sarmatian and Meotis-Pontian formations) and Quaternary alluvial fan deposits. This MSTRB basin is characterized by high-amplitude, high-continuity reflections that onlap on top of low-amplitude, low-continuity pre-growth strata reflections in the seismic reflection profile (Fig. 3).

According to interpreted seismic profiles, the growth strata geometry exhibits the MSTTB formation dynamics. Structural evolution of the MSTTB is controlled from the south by the LC and from the north by the GC orogens' frontal parts. Based on the seismic profile, we document two stages of kinematic evolution of late Miocene growth strata. The seismic profile reveals two Late Miocene growth packages (I, II) (Fig. 3). The seismic profile shows that the southern part of the western KFB was deformed and uplifted by south-vergent passive-back thrusting at the triangle zone. The first stage is dominated by south-vergent passive-back thrusting. The second stage of dominance is distinguished by both thrust wedge and passive-back thrusting. The northern part of the basin was involved in the deformation later, and its formation was related to the movement of the masses in the N-S direction. Unfortunately, later forms of the Upper Miocene growth strata are poorly observed on the available seismic profiles (Fig. 3).

The MSTTB differs from the classical type of thrust-top basins (Ori & Friend, 1984) and is not related to any of the end-member thrust sequence models (Butler, 1987). It was formed as a result of the convergence of the frontal parts of two orogens and is located between the south-vergent passive-back thrust and the south-vergent Bitsmendi structure.

In common with other convergence zones (e.g., Fu et al., 2010; Toscani et al., 2014), the central LC-GC convergence zone is a unique example of the intracontinental ongoing mountain building within the Arabia-Eurasia collision system. We suggest that the results of this study may also shed light on the structural evolution of thrust-related basins in other convergence zones.

Conclusions

The results obtained through the interpretation of the seismic profile allow us to assume:

- The MSTRB, situated in the western KFB, formed as a result of the convergence of two orogens' frontal parts is located between the south-vergent passive-back thrust and the south-vergent wedge thrust.
- The seismic profile reveal two stages of the kinematic evolution of the Late Miocene growth strata, represented by two Late Miocene growth packages (I and II). The first stage is dominated by south-vergent passive-back thrusting. The second stage of dominance is distinguished by both south-vergent thrust wedge and south-vergent passive-back thrusting.

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შეცოცებასთან დაკავშირებული აუზი ორიოროგენის კონვერგენციის ზონაში დასავლეთ მტკვრის აუზში

ვ. ალანია*, ო. ენუქიძე*, ნ. ყვავაძე*, ა. რაზმაძე, თ. ბერიძე**, მ. ბეკურაშვილი§, თ. შიხაშვილი***

** ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, მ. ნოდიას გეოფიზიკის ინსტიტუტი, საქართველო*
*** ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, ალ. ჯანელიძის გეოლოგიური ინსტიტუტი, საქართველო*
§ საქართველოს ტექნიკური უნივერსიტეტი, სამთო გეოლოგიური და მთის მდგრადი განვითარების ფაკულტეტი, თბილისი, საქართველო

(წარმოდგენილია აკადემიის წევრის თ. ჭელიძის მიერ)

წარმოდგენილ ნაშრომში გამახვილებულია ყურადღება სეისმური პროფილის გამოყენებით დასავლეთ მტკვრის ფორლანდურ აუზში, მცირე კავკასიონსა და კავკასიონის ოროგენების კონვერგენციის ზონაში განვითარებული გვიანმიოცენური მზარდი ნალექების გეომეტრიასა და კინემატიკაზე. სეისმური პროფილისა და ზედაპირული გეოლოგიური მონაცემების მიხედვით დასავლეთ მტკვრის ფორლანდურ აუზში გამოიყო შეცოცებასთან დაკავშირებული აუზი და ეწოდა მუხრან-საგურამოს შეცოცებასთან დაკავშირებული აუზი, რომლის სტრუქტურული ევოლუცია სამხრეთიდან მცირე კავკასიონის, ხოლო ჩრდილოეთიდან კავკასიონის ოროგენების ფრონტული ნაწილებით კონტროლირდებოდა. სეისმური პროფილის საფუძველზე დაფიქსირდა გვიანმიოცენური მზარდი ნალექების კინემატიკური ევოლუციის ორი ეტაპი. პირველ ეტაპზე დომინირებს პასიური ზურგის შეცოცება, ხოლო მეორეზე, როგორც სოლისებრი, ასევე პასიური ზურგის შეცოცება.

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