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Geophysics

Seismic Evidence of Normal Faulting in the Rioni Foreland Fold and Thrust Belt, Georgia

Victor Alania[*], Anzor Giorgadze[**], Tamar Beridze[§], Onise Enukidze[*], István Fórizs[§§,#], Levan Gorgidze[**], Giorgi Melikadze[*], Laszlo Palsco[##], Alexander Razmadze[§]

[*]*Institute of Geophysics, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[**]*Faculty of Mining and Geology, Georgian Technical University, Tbilisi, Georgia*
[§]*A. Janelidze Institute of Geology, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[§§]*Institute for Geological and Geochemical Research, Research Centre for Astronomy and Earth Sciences, ELKH, Budapest, Hungary*
[#]*CSFK, MTA Centre of Excellence, Budapest, Hungary*
[##] *Department of Isotopes, Institute of Nuclear Research, Hungarian Academy of Sciences, Budapest, Hungary*

(Presented by Academy Member Tamaz Chelidze)

Our study is focused on the structural geometry of the outer Rioni foreland fold-and-thrust belt disposed in western Georgia. The structural architecture of the outer Rioni foreland fold-and-thrust belt has been interpreted using a seismic reflection profile. The interpreted seismic profile shows that the compressional structures are represented by Tsaishi fault-propagation fold and duplexes. The seismic profile reveals the occurrence of normal faults within the pre-orogenic sedimentary strata. Normal faults are inherited from the Middle Jurassic-Paleogene and represented by four sets of extensional faults separated by detachment levels. The origin of extensional faults is related to the Jurassic-Paleogene evolution of the outer Greater Caucasus marginal basin. *© 2023 Bull. Georg. Natl. Acad. Sci.*

Rioni foreland fold-and-thrust belt, seismic profile, fault-propagation fold, duplex, normal fault

The Rioni foreland fold-and-thrust belt (RFFTB) is one of the main oil-bearing and hydrothermal provinces of the west Georgia [1,2]. Many structural studies mainly based on seismic data, were undertaken in the RFFTB during the past decade. They were predominantly focused on the study of compressional structures and kinematic evolution of the RFFTB that are exposed on the seismic lines [2-6]. To understand the evolution of the extensional basin during the Jurassic-Eocene time, we used a seismic reflection profile from the outer RFFTB. In this paper, the extensional faults identified in the seismic profile reflect that these normal faults are related to four extensional sets.

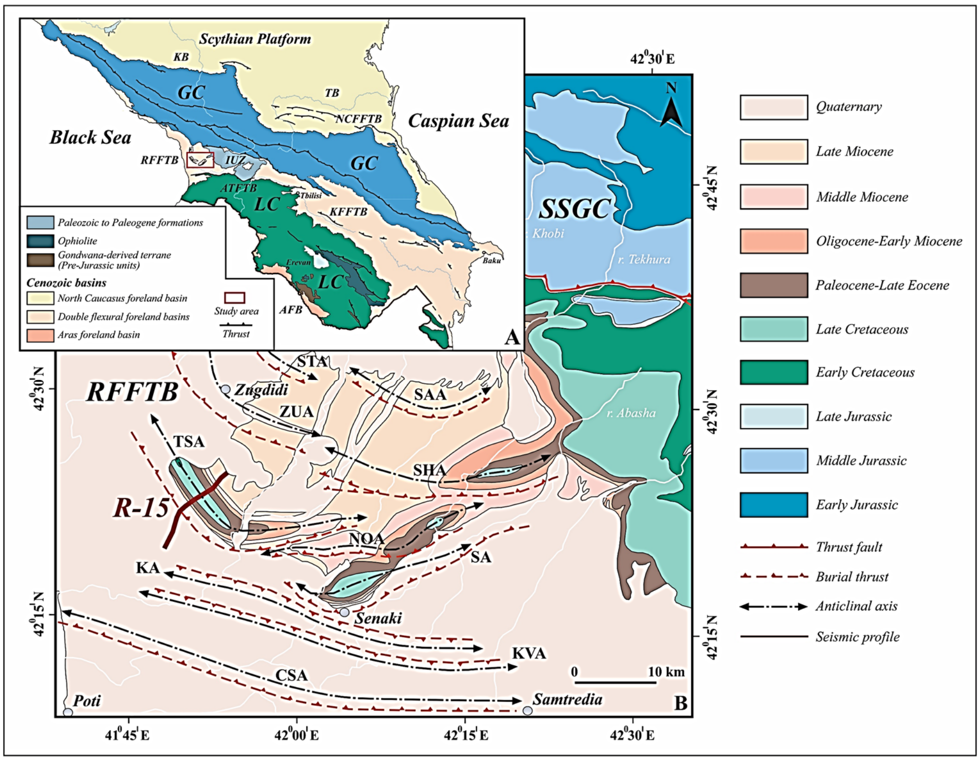

Fig. 1. (A) Tectonic map of the Caucasus [3]. (B) Geological map of RFFTB and surrounding area [2-4]. Abbreviations: GC-Greater Caucasus, LC-Lesser Caucasus, RFFTB-Rioni foreland fold-and-thrust belt; IUZ-Imereti uplift zone; ATFTB-Achara-Trialeti fold-and-thrust belt; KFFTB-Kura foreland fold-and-thrust belt; NCFFTB-North Caucasus foreland fold-and-thrust belt; KB-Kuban Basin; TB-Terek Basin; AFB-Araks foreland basin; SSGC-Southern Slope of Greater Caucasus; CSA-Chaladidi-Sagvamischao anticline; KVA-Kvaloni anticline; KA-Khobi anticline; SA-Senaki anticline; NOA-Nokalakevi anticline; TSA-Tsaishi anticline; SHA- Sashurgaio anticline; ZUA-Zugdidi anticline; STA-Satanjo anticline; SAA-Sarakoni anticline.

Geological Setting

Deformation of the Rioni foreland basin during the late Alpine time was controlled by the action of two opposing orogenic fronts, the Lesser Caucasus retro-wedge to the south and the Greater Caucasus pro-wedge to the north (Fig. 1A) [3,4]. North and central parts of the Rioni foreland basin during the Middle Miocene-Pleistocene time were deformed and shortening is concentrated at the outer part of the Greater Caucasus pro-wedge [4].

The RFFTB is a part of the Greater Caucasus pro-wedge (Fig. 1B). Sedimentary infill of the RFFTB (more than 7 km) consists of pre- and syn-orogenic sequences [3,4] (Fig. 2). The pre-orogenic sequences comprise Jurassic-Late Eocene shallow and deep marine deposits [2,7,8]. The syn-orogenic sequences are composed of the foreland basin (Oligocene-Early Miocene) and syn-tectonic strata [4].

The main style of deformation within the thin-skinned RFFTB is represented by a set of growth fault-related folds, triangle zones, duplexes, and a series of thrust-top basins [3]. The RFFTB system consists of several major anticlines and is represented mainly by fault-propagation folds detached along the basal thrust which soles within the Late Jurassic evaporates [2-10]. Recent GPS and earthquake data indicate that the RFFTB is still tectonically active [11-13].

Data and Methods

Fault-related folding theories [14] were used in the interpretation of the 2D time-migrated seismic reflection profile (R-15) (Fig.3). The surface

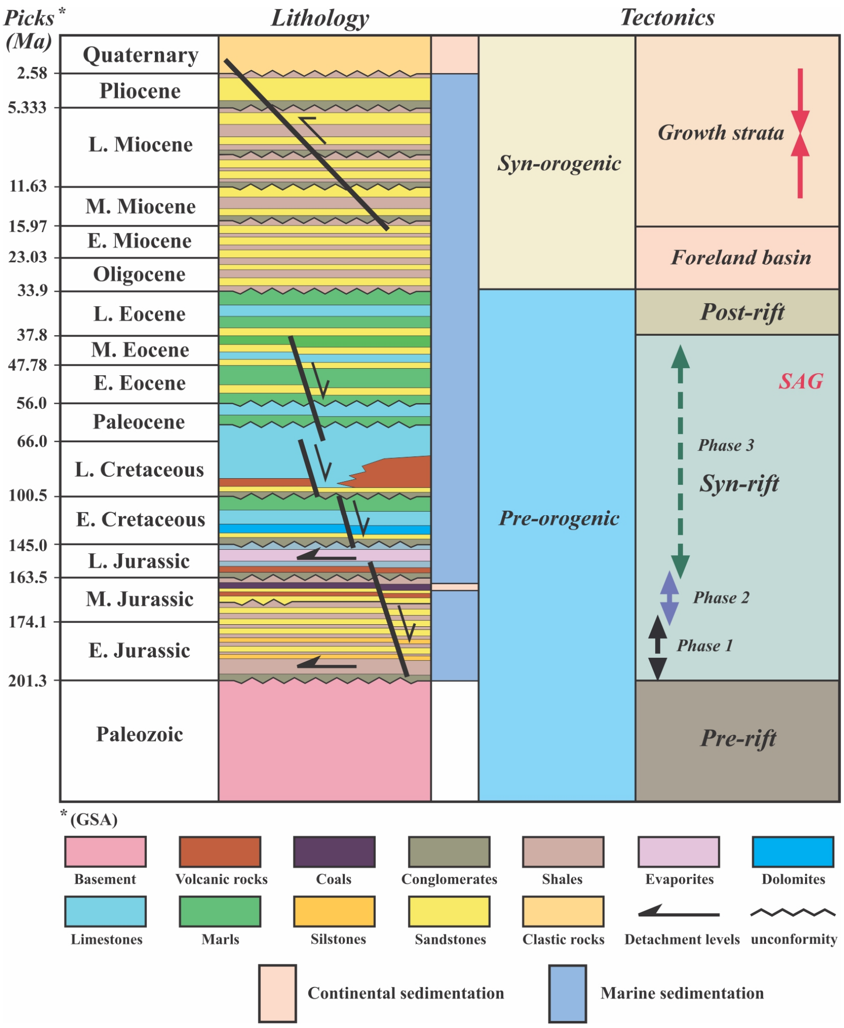

Fig. 2. Tectonostratigraphic chart of the Rioni basin and surrounding area [3].

geological information was obtained from the 1:100,000 scale geological map of the study area [3] (Fig. 1B). For the interpretation of the 2D time-migrated seismic profile and restored cross-sections, the Move software was used.

Results

Seismic profile R-15 of the outer RFFTB illustrates the overall geometry of the deep structure and the main structural features. The interpretation comprises five horizons: the top of the Late Jurassic, the top of the Early Cretaceous, the top of the Late Cretaceous, the top of the Oligocene, and the top of the Miocene. The interpreted seismic profile R-15 shows that the compressional structures are represented by south-vergent Tsaishi anticline and south-vergent duplexes. The formation of these structures is related to two detachment levels and controls the kinematic evolution of the outer RFFTB. Two detachment levels that join on the termination of the duplexes developed under the Tsaishi anticline are well-observed on the interpreted seismic profile R-15 (Fig. 3). The interpreted seismic profile shows that the Tsaishi anticline is a fault-propagation fold with broken by thrust faults front limb. The back limb of the Tsaishi anticline is complicated by back thrusts (Fig. 3). The top section is represented by Tertiary, Cretaceous, and Late Jurassic strata. The base of the section is marked by the upper detachment, which correlates to the evaporates of the Late Jurassic.

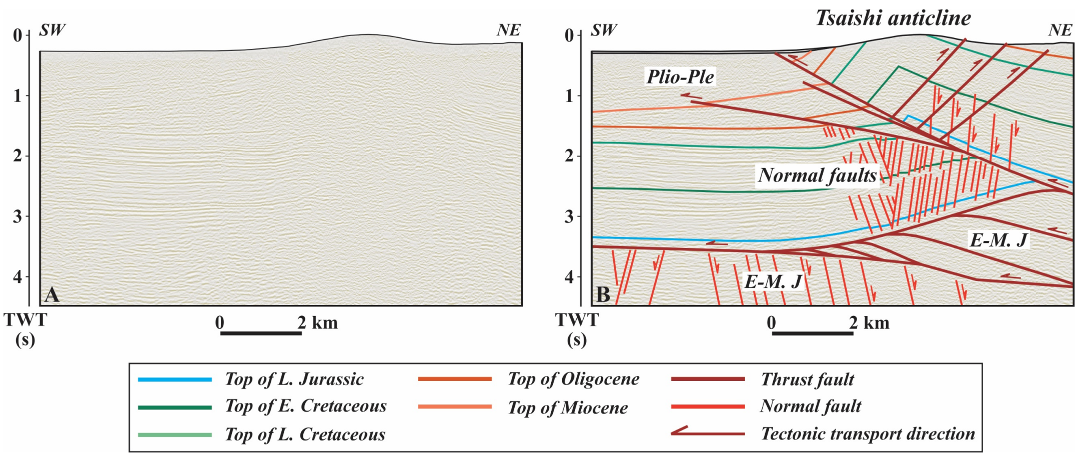

Fig. 3. (A) Uninterpreted and (B) interpreted seismic reflection profile R-15. Location is shown in Figure 1B. Abbreviations: E-M. J – Early-Middle Jurassic; Plio-Ple – Pliocene-Pleistocene.

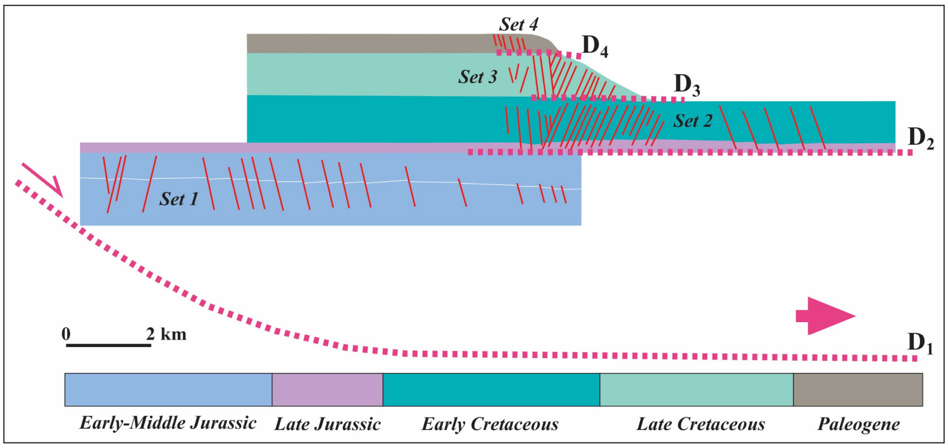

Fig. 4. Restored cross-section. Abbreviations: D1-D4 – Detachments.

The lower section is represented by duplexes and is composed of Early-Middle Jurassic rocks (Fig.3).

Seismic profile R-15 (Fig.3) reveals the occurrence of normal faults within the pre-orogenic sedimentary strata. These faults are inherited from the Middle Jurassic- Paleogene and are related to several phases of extension. Figure 4 shows the restored cross-section of the pre-orogenic sedimentary sequences. Four sets of extensional brittle faults are separated by detachment and development within the Early-Middle Jurassic, Early Cretaceous, Late Cretaceous, and Paleogene strata (Figs. 3, 4). These normal faults define a series of tilted blocks forming important half-grabens. The normal faults bounding the different tilted blocks may be related to several detachment horizons. Upper sets of extensional brittle faults develop in late Jurassic-Paleogene strata separated by a thin zone of ductile detachment. Seismic profile R-15 indicates that most normal faults are not re-activated during compressional deformation. The origin of these extensional fault sets is related to the evolution of the Greater Caucasus marginal basin. A similar picture was established in the western Kura foreland fold-and-thrust belt [15].

Conclusion

The interpretation results showed the following:

- The interpreted seismic profile shows that the compressional structures are represented by Tsaishi fault-propagation fold and duplexes.

- The seismic profile reveals the occurrence of normal faults within the pre-orogenic sedimentary strata.
- Normal faults are inherited from the Middle Jurassic-Paleogene and are represented by four sets of extensional brittle faults that are separated by detachment.

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გეოფიზიკა

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ვ. ალანია*, ა. გიორგაძე, თ. ბერიძე§, ო. ენუქიძე*, ი. ფორიცი§§,#, ლ. გორგიძე**, გ. მელიქაძე*, ლ. პალსკო##, ა. რაზმაძე§**

**ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, მ. ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი, საქართველო*
*** საქართველოს ტექნიკური უნივერსიტეტი, სამთო-გეოლოგიური ფაკულტეტი, თბილისი, საქართველო*
§ ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, ალ. ჯანელიძის გეოლოგიური ინსტიტუტი, თბილისი, საქართველო
§§ გეოლოგიური და გეოქიმიური კვლევების ინსტიტუტი, ასტრონომიისა და დედამიწის შემსწავლელ მეცნიერებათა კვლევითი ცენტრი, ბუდაპეშტი, უნგრეთი
 # გარდამავალი კვლევების ცენტრი, ბუდაპეშტი, უნგრეთი
უნგრეთის მეცნიერებათა აკადემია, ბირთვული კვლევების ინსტიტუტი, იზოტოპების დეპარტამენტი, ბუდაპეშტი, უნგრეთი

(წარმოდგენილია აკადემიის წევრის თ. ჭელიძის მიერ)

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