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Geology

Petrology of Late Pliensbachian-Early Toarcian Volcanogenic Formations of Trans-Alazani Kakheti and Prospects of Using them as Construction and Facing Materials

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(Presented by Academy Member David Shengelia)

ABSTRACT. In the paper, on the example of the river Stori outcrops, general regularities of the development and geological-petrological peculiarities of basaltic magmatism revealed in Late Pliensbachian-Early Toarcian clay shale series of the Tsiklauri suite are considered and the results of investigations of mineralogical-petrologic and standard physical-mechanical peculiarities of volcanic products are analyzed. Connection of lava flows with the zones of magma-bearing deep-seated faults of general Caucasian strike traced in the Stori river-valley almost over 4.5km along strike is established. The products of volcanism are characterized by massive pillow and brecciate textures. Porphyritic structure with intersertal and hyalopilitic matrix dominates mainly, though diabase structures are observed as well. The volcanic complex underwent considerable postmagmatic hydrothermal change: main rock-building minerals (Labrador, augite) are completely or partially replaced by products of their alteration (amphibole, chlorite, zoisite, epidote, calcite, saussurite, limonite) and as a result dark grey, almost black basalt rocks attain light grey-green-burgundy coloring that is finally fixed as a high decorative feature of handicraft and facing rocks. The greatest part of basalts belongs to sub-alkali series, the lesser – to alkali series. According to physical-mechanical properties they represent superdense, ultra-hard, nonporous, frostproof and wear-resisting rocks of first class, which can be successfully used as a building and facing material. In the Kakhet region, on the base of this complex, enterprises (plants) for stone mining and processing can be established; they will contribute significantly to the development of the region's infrastructure and speed up secular and clerical building activities. *© 2016 Bull. Georg. Natl. Acad. Sci.*

Key words: Basalt, facing, subalkali, magmatism

The region of trans-Alazani Kakheti covers the territory from the Alazani riverhead to the state boundary of Azerbaijan. Geotectonically it belongs to the Kazbegi-Lagodekhi zone of the Lower-Middle Jurassic slate series of the Caucasus overthrust-fold system. The zone from the south is bordered by Upper Jurassic-Lower Cretaceous terrigene-carbonaceous flysch of the Gagra-Java Zone [1]. The

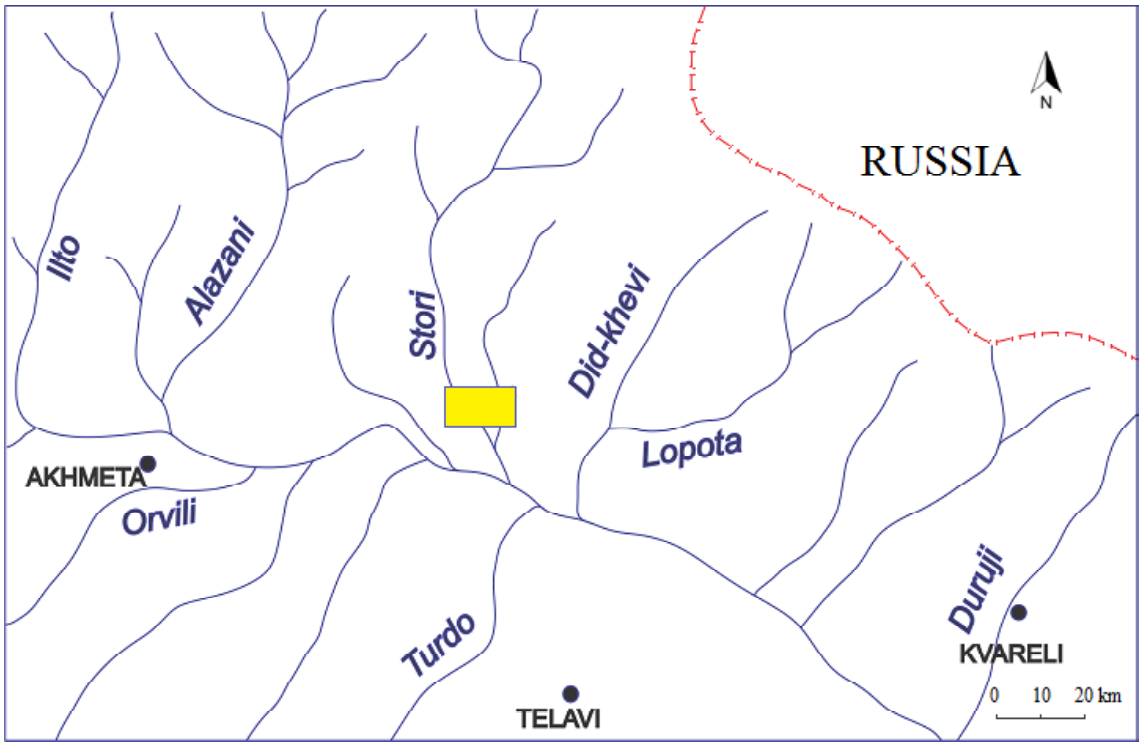

Fig. 1. Spreading Area of Late Pliensbachian-Early Toarcian Volcanite Outcrops in the Stori River Basin

series of slates are formed as a marginal sea facies under conditions of its intensive extension on Paleozoic basement; it participates in the south bending Stori-Lopota anticlinal structure of general Caucasian strike.

The oldest formations of the slate series is known as the Stori suite and in a deeply incised Stori river gorge it is exposed in the axial strip of the above anticline. The suite is built up of alternation of arkose sandstone-gravelstones and clay shales, which seldom contain sheets of quartz-bearing albitophyres of ryolite-dacitic composition. Volcanogenic-sedimentary complex of the Stori suite under the influence of intensive cataclasis and hydrothermal processes they metamorphosed into sulfide containing albite-chlorite quartz- and chlorite-sericite-quartz bearing metasomatites. In the territory of trans-Alazani Kakheti fragments of the Stori suite are exposed also on the Speroza ridge, in deep river-gorges of the Didkhevi, Lapota and Matsimi. The mentioned formations don't encounter fauna that is why the view of the researchers on their age and genesis varies. Some researchers attribute them to the Upper Paleozoic [2}and some to the Upper Paleozoic-Triassic [3] but the greatest part of the scientists dates them as the Early Jurassic [4, 5]. Faunally dated Late Sinemurian-Early Pliensbachian slate series stratigraphically conformably continue the Stori suite [6, 7]. They are followed by the faunally dated Pliensbachian Tsiklauri suite. In the Upper part of the Tsiklauri suite the object of our study – basalt volcanism is established [8] (Fig.1).

At present, the above volcanic complex is recorded in many areas on the territory of Khakheti, but only the Kvachadali exposure is studied with the view of its prospects as a facing raw material. The researches gave positive results and it is licensed for processing. Pliensbachian deposits are in compete conformity continued by the faunally dated sedimentary complex of the Toarcian age, in the region it is known under the name of the Duruji [9] and Pankisi [5] suites.

Outcrops of Lower-Middle Jurassic sediments on the southern slope of the Kakheti Caucasus is termi-

nated by the Aalenian-Lower Bajocian (the Almati suite); it conformably continues faunally dated Toarsian sediments and represents alternation of lithologically nongraded psammit-aleurite-pellitic slates and argillites.

Characteristics of the Products of Volcanism

In the Stori river basin spreading areal and thicknesses of the volcanic complex was determined with the methods of detailed lithostratigraphic and petrological sections. The detailed sections were done directly in the basins of the river Stori and its tributaries Svianas Khevi and Eshmakis Khevi.

In the Stori river-channel the main exposures of volcanites are covered with alluvium, though the large basalt boulders (from 3-5 to 25Ч40 m^3 and more in size) that collapsed from the slopes are widespread; on their polished surface real color end textural peculiarities of altered basalts are distinct (Fig. 2). Main outcrops of the Basalt complex is well observed on the section along Akhmeta-Omalo motor road (Fig.3).

The section starts 250 m south of the "Kakliani valley" (GPS altitude H=738m, with coordinates N42є11.460; EO 46є27.270); the fault zone built up of dark grey, almost black clay shales is exposed (inclination azimuth 30-35є <89-85) where the contorted and confused slates are cut by quartz veinlets; apparent thickness amounts 23m. In the section after the 45m break 11m thick first outcrop of light greenish-grey basalts is exposed; it is weathered and fissured on the surface and is cut by 1.3-2.0 cm thick unoriented veinlets of white and light green quartz-epidote. To the South, after 25 m break, a packet of transformed light grey, silicified clay slates (65 m thick) of massive texture with aleuro-psammitic bands is exposed. From the above exposure towards the section again 160 m discontinuity is observed. Then outcrop of the volcanic sheet starts (H=729; N 42є 11.341; EO 45є27.111). Its apparent thickness is 45m. Volcanites are characterized by a well expressed pillow texture. Size of the "pillow" varies from 3Ч5 cm to 1.5Ч3.0 m. The "pillows" in the center are of burgundy color, to the periphery they attain greenish-burgundy coloring. Such transition of colors is better observed in the varieties of greater

Fig. 2. Boulder bed in the Stori river-channel

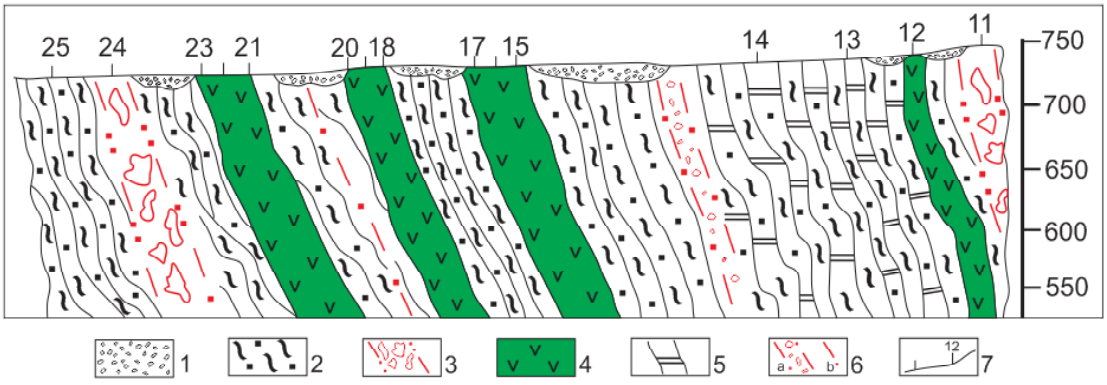

Fig. 3. Section of outcrop of the volcanic complex along Stori motor road
1-Eluvial-deluvial deposits, 2 – Pliensbachian clay shales with 0.1-0.5 cm aleurite bands, 3 – marginal brecciation zone of a deep-seated fault, 4 – lava sheets, 5 – silicified massive clay shales with aleuro psammitic bands, 6 – shear zone (a); shear plane (b); 7 – sampling point and its number

Table 1. Chemical analysis of the Stori river-valley basalts

№	Sample №	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	PPP	Total
1	56	46.64	1.30	15.53	2.57	7.92	0.24	5.35	9.27	5.35	1.21	0.45	0.31	3.94	100.08
2	65	51.23	1.35	12.75	2.37	6.81	0.14	5.16	8.74	6.92	0.78	0.42	0.44	2.71	99.82
3	108	49.54	0.97	14.64	3.16	6.67	0.18	5.26	9.46	5.25	0.81	0.38	0.43	3.03	99.78
4	252	49.43	1.10	14.54	2.84	8.12	0.20	6.18	7.72	6.28	0.84	0.77	0.27	2.05	100.32
5	301	51.17	0.75	14.43	2.16	7.05	0.16	7.13	8.54	6.08	0.65	0.22	0.08	1.85	100.27
6	460	50.64	1.12	13.38	3.05	7.32	0.22	6.48	9.04	5.74	1.27	0.52	0.12	1.30	100.20
7	724	48.58	0.87	15.26	3.26	6.85	0.16	7.10	7.76	6.24	1.35	0.63	0.34	1.78	100.18
8	747	47,78	0.88	14.65	3.56	6.54	0.28	6.78	9.04	6.56	1.26	0.50	0.38	2.08	100.29

Basalt complex: 1. Central part of pillow lava; 2 – baking crust of pillow lava; 3. Dolerite basalt; 4. Basalt with spheroidal-crown-like structure; 5. Basalt with radiolith structure; 6. Basalt with diabase structure; 7 – altered (green) dolerite; 8 – altered (hematitized) pillow lava

size. Intarpillow clastic cement is greener than the pillows. Basalts are fissured; earlier fissures filled up with quartz –calcite and epidote veinlets are observed as well.

After an unexposed 65m interval again follows 30m thick exposed greenish-grey volcanic body of brecciate pattern. Size of fragments varies from 2.5Ч4.0cm to 25Ч32cm. Cement on a fresh fragment is green and on the weathered surface it has a greenish-grey coloring. Conformable contact of the lava flow base with 75m thick clay shale packet (inclination azimuth 25-27є<68-70є) is distinctly observed.

One more basalt lava flow (thickness 35m) with well expressed pillow structure follows the slate packet to the south. Baking crust of pillows is striated; it is characterized by a brownish coloring and between the pillows passes into green aphyric cement. The southern boundary of the magma-bearing zone coincides with a 20-25m thick zone of contorted and confused clay shales.

Table 2. Mean Values of Physical-Mechanical Properties of Rocks /Full Program Standard Analysis/

Sample №	Dampness, %	Density					Porosity			Water absorption, %		Wear			Ultimate uniaxial compression strength, mega/Pa						Strength loss due to water saturation %		Frost resistance grade
		Mean			Real (of particles) g/cm³										Dehydrated rock		Water saturated rock			10 water saturated cycles after freeze-thaw			
		Factual, kg/m³	Class [5]	Standard-driven [4], kg/m³	Factual	Mean according to literature sources [6;7;8]	Factual, %	Class [5]	Standard-driven [5], %	Factual	Standard-driven [4]	Factual, g/cm²	Class [4]	Standard-driven [4], g/cm²	Factual	Standard-driven [4]	Factual	Standard-driven [5]	Class [5]		Factual	Standard-driven [4]	
1	0,25	2920	1	>2500	3,01	2,92	0,034	1	=0,3	0,10	<0,75	0,96	2	<1,0	142	80	132	>120	1	121	7	<30	F50
2	0,34	3020	1	>2500	3,09	2,92	0,027	1	=0,3	0,17	<0,75	0,94	2	<1,0	160	80	152	>120	1	146	5	<30	F50

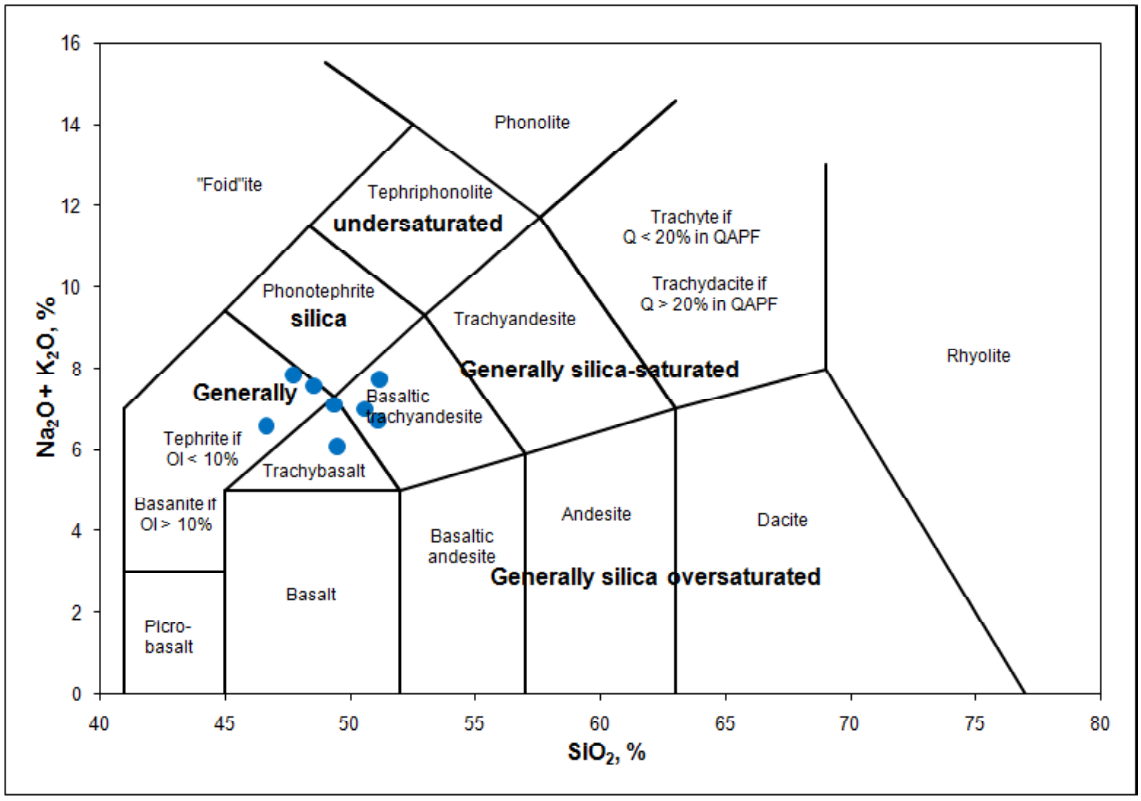

Fig. 4. Na_2O+K_2O-SiO_2 classification diagram [LeBas et al., 1986] for the Stori river-gorge basalts

Petrologic and Physical-Pechanical Characteristics of the Products of Volcanism

The volcanites under study are characterized by diversity of colors – grey, green, burgundy and their color varieties. They are intersected by veinlets of epidote, epidote-chlorite, quartz and calcite of different orientation and color and are characterized by massive pillow and brecciate textures. The volcanites are represented mainly by porphyritic structure with intersertal and hyalopilitic matrix, though diabase (ophitic) structures are observed as well.

Main rock-building minerals are: basic plagioclase (labrador), monoclinal pyroxene (augite, titanaugite) and products of their alteration: amphibole, chlorite, zoisite, epidote, calcite, saussurite, limonite.

Microscopic study of volcanites, silicate analyses of their samples (Table.1) and interpretation of distribution of figured points on the Na_2O+K_2O-SiO_2 classification diagram [10] (Fig.4) established that the studied volcanic complex belongs to the rock series intermediate between subalkali and alkali basalts.

Standard physical-mechanical characteristics of volcanites as construction and facing raw material were determined at G.Tsulukidze Mining Institute in the Rock, Construction Material Properties and Quality Control Department: 2 samples by complete and 6 by concise standard program (Table. 2, 3); interpretation of the obtained results established that the analyzed samples belong to super- dense, super-firm, non-porous, frost proof and wear resistant – first class rocks. They can be used in producing construction facing stone slabs, memorial products and for other purposes.

Conclusions

1. The basalt volcanic complex widely presented in the mid-stream of the river Stori at the altitude of 370-1250m from the sea level is connected with the magma-bearing deep-seated fault of general Caucasian strike and is traced over 4.5km. In the fault zone 10-45m

Table 3. Mean Values of Physical-Mechanical Properties of Rocks /Concise Program Standard Analysis/

Sample №	Dampness	Density			Real (of particles) g/cm^3		Water absorption, %		Porosity		
		Factual, kg/m^3	Class [5]	Standard-driven [4], kg/m^3	Factual	Mean according to literature sources [6;7;8]	Factual	Standard-driven [4]	Factual, %	Class [5]	Standard-driven [5] , %
1	0.32	2840	1	>2500	2.98	2.92	0.06	<0.75	0.053	1	≥0.3
2	0.27	2910	1	>2500	3.04	2.92	0.59	<0.75	0.048	1	≥0.3
3	0.21	2930	1	>2500	3.05	2.92	0.07	<0.75	0.045	1	≥0.3
4	0.29	2900	1	>2500	3.06	2.92	0.22	<0.75	0.059	1	≥0.3
5	0.21	2850	1	>2500	3.03	2.92	0.22	<0.75	0.067	1	≥0.3
6	0.29	2870	1	>2500	2.99	2.92	0.13	<0.75	0.046	1	≥0.3

thick lava sheets echelon-likely replace each other. Their total thickness exceeds 100m. Lava flows are separated from each other both by altered (carbonatized and silicified) and undisturbed shale bands (10-50m thick). Probable reserve of the volcanic complex is 4.5000Ч100Ч50 = 22.5 million m^3 down to 50m and apparent vertical range of the complex exceeds 500m.

2. According to petrochemical data the volcanic complex belongs mainly to subalkali and partially to alkali basalts. They are characterized by diversity of colors – grey, green, burgundy and their color varieties that is fixed as a high decorative feature of the rocks.

3. According to physical-mechanical properties they are superdense, nonporous, frost resistant and wear resistant rocks, which as a row material, without restriction can be used for exterior and interior finishes, manufacturing of abaculus and memorial-handicrafts.

Recommendations

Early Jurassic metamorphosed basaltic complex under study that was revealed in the mid-course of the river Stori by its parameters, physical-mechanical properties and decorative characteristics, represents a raw stock of high quality for building purposes and manufacturing of handicraft. On the base of this complex, highly efficient enterprises (plants) for stone mining and processing can be established.

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გეოლოგია

ალაზანგაღმა კახეთის გვიანპლიონსბაზურ-ადრეტოარსული ვულკანოგენური წარმონაქმნების პეტროლოგია და მათი სამშენებლო და მოსაპირკეთებელ ქვებად გამოყენების პერსპექტივები

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(წარმოდგენილია აკადემიის წევრის დ. შენგელიას მიერ)

სტატიაში განხილულია ალაზანგაღმა კახეთის გვიანპლიონსბაზურ-ადრეტოარსულ-წიკლაურის წყების ფიქლების სერიაში გამოვლენილი ბაზალტური მაგმატიზმის განვითარების ზოგადი კანონზომიერებანი და გეოლოგიურ-პეტროლოგიური თავისებურებანი მდ. სტორის გამოსავლების მაგალითზე; გაანალიზებულია ვულკანური პროდუქტების მინერალოგიურ-პეტროლოგიური და სტანდარტული ფიზიკურ-მექანიკური თვისებების კვლევის შედეგები; დადგენილია, ლავური განფენების კავშირი საერთო კავკასიური მიმართების მაგმამატარებელ სიღრმული რღვევის ზონებთან, რომელიც მდ. სტორის აუზში მიმართებაზე თითქმის 4,5 კმ-ზე გაიდევნება. ვულკანური პროდუქტებისათვის დამახასიათებელია მასიური, ბალიშა და ბრექჩიული ტექსტურები; სჭარბობს პორფირული სტრუქტურა ინტერსერტალური და ჰიალოპილიტური ძირითადი მასით; აღინიშნება დიაბაზური სტრუქტურაც. ვულკანურ კომპლექსს განცდილი აქვს მნიშვნელოვანი პოსტმაგმური ჰიდროთერმული გარდაქმნა, მთავარი ქანმაშენი მინერალები (ლაბრადორი, ავგიტი) ნაწილობრივ, ან მთლიანად ჩანაცვლებულია მათი შეცვლის პროდუქტებით (ამფიბოლი, ქლორიტი, ცოიზიტი, ეპიდოტი, კალციტი, სოსურიტი, ლიმონიტი), შედეგად მუქი-ნაცრისფერი, თითქმის შავი ფერის ბაზალტური ქანები იძენენ ღია ნაცრისფერ-მწვანე-შინდისფერ შეფერვას, რაც საბოლოოდ ფიქსირდება, როგორც სანახელავო და მოსაპირკეთებელი ქანების მაღალი იერსახის დეკორატიული მახასიათებელი.

ბაზალტების უმეტესობა სუბტუტე რიგს მიეკუთვნება. ფიზიკურ-მექანიკური მახასიათებლებით ბაზალტები წარმოადგენენ დეკორატიული იერსახის მქონე ზემკვრივ, ზემტკიცე, არაპოროვან, ყინვამედეგ და ცვეთამედეგ პირველი კლასის ქანებს, რომლებიც წარმატებით შეიძლება იქნეს გამოყენებული სამშენებლო და მოსაპირკეთებელ მასალად. ამ კომპლექსის ბაზაზე კახეთის რეგიონში შეიძლება შეიქმნას ქვის მომპოვებელი და დამუშავებელი საწარმოები, რომლებიც მნიშვნელოვან წვლილს შეიტანს რეგიონის ინფრასტრუქტურის, საერო და საეკლესიო სამშენებლო სამუშაოების დაჩქარებული ტემპებით განვითარებაში.

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