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Volcanology

The Late Pliensbachian - Early Toarcian Volcanic Complex of the Shaly Zone of the Greater Caucasus Southern Slope as Raw Material for Ornamental Stone (the Kvachadala Deposit)

Karlo Akimidze

I. Javakhishvili Tbilisi State University

(Presented by Academy Member D. Shengelia)

ABSTRACT. Three levels of volcanism are known in the shaly series of the southern slope of the Greater Caucasus. The most widespraed are Late Pliensbachian-Early Toarcian subalkaline basalts, evidenced as separate outcrops all over the territory of Georgia – from the upper reaches of the river Bzybi up to the border between Georgia and Azerbaijan.The author investigated analogous basaltoids, revealed in the upper reaches of the river Alazani, in the Kvachadala segment, presenting the results in this paper. Considering the data, the mentioned complex has been found to absolutely satisfy all the technical and technological requirements, it has fine external texture and is perfect raw material for manufacturing ornamental stone decorative tiles. Besides, according to the stable homogeneity of the basaltic complex within the limits of its spread, the author assumes it to be prospective as raw material for manufacturing ornamental stone blocks and tiles and recommends to carry out geological studies in this direction. *© 2009 Bull. Georg. Natl. Acad. Sci.*

Key words*: texture, structure, aggregate, microlitite, lava, plate.*

By the present time within the limits of spreading of Lower-Middle Jurassic shaly deposits of the southern slope of the Greater Caucasus three stratigraphic levels of effusive magmatism manifestation have been confidently established: Sinemurian-Early Pliensbachain and, Late Pliensbachian-Early Toarcian volcanites are most widespread in Georgia [1]. They are attested as isolated outcrops in the upper reaches of the Bzybi [1] and Rioni rivers [2], in Khevi-Khevsureti [3] and on the territory of Trans-Alazanian Kakheti [4].

At the headwaters of the right tributaries of the Alazani - the Kvachadala and Lamazuri rivers outcrops of volcanogenic-sedimentary series have been revealed. According to the data of their geological-petrological study, the volcanites, constituting the series, have been attributed to the complex of Late Pliensbachian-Early Toarcian subalkaline basaltoids [5, 6].

The basaltic complex in the upper reaches of the rivers Kvachadala and Lamazuri is distinguished for its variegated coloration-combination of gray, green and bluish-green and its massive structure; thus they may be used in manufacturing decorative stone blocks and tiles. In this connection the author carried out special geological researches in the Kvachadala segment and proved that these volcanic rocks may be qualified as raw material of ornamental stone.

The segment is located in the upper reaches of the Kvachadala and Lamazuri rivers, 10-12 km north-east of the Khadori Hydro Electric Power Plant. The volcanogenic-sedimentary rock mass under consideration constitutes the limb of the syncline structure.

It crops out in the Lamazuri river bed at a height of 2050-2180 m. Volcanites occupy the upper part of the aleuropelitic thickness. They are represented by three sheets (50, 12 and 15 m thick).

The first, lowermost, 50 m sheet concondantly interlies laminated black aleuropelitic shales with small pyrite concretions. At the sole of the body the shale members have lighter colour and are turned into adinole (10-12 cm); at the roof the shales are quite fresh. At the lower part the sheet is represented by light green brecciated rocks (0.8 -1.2 m thick). The debris constitutes 35-37% of the rock. The outlines of derbis are fused, 1x3 cm or more in dimensions. There are distinguished breccias of light green and dark colours.

Light-green breccias are represented by aleuropelitic formations of sedimentary origin whereas dark green breccias are of volcanogenic genesis and relict microlitic and ophytic textures are established in them. Lava, taking the role of cementing material, has been recrystallized and turned into granular-scale aggregate of albite-chlorite-epiclote composition. The author considers the rock to be tuff breccia.

The quantity of sedimentary breccia gradually decreases and simultaneously tuff breccia turns into lava-breccias (with 1.0-4.0 m interval) and nearer to the roof the latter becomes massive, having relict dolerite texture. Plagioclase has turned into saussurite and pyroxene into a chlorite-epidote aggregate. The changed dolerites occupy the central part of the roof (5.0-30.0 m) and the body is completed (30.0-50.0 m) by pillow basalts. Large pillow formations have ellipsoid structure and the smaller ones spheric structure.

The space between pillows is filled with siliceous, epidote-carbonate or chlorite-carbonate material. The pillow bodies have hardening crust represented by devitrificated glass. Towards the center the rock assumes intersertal structure, built of curved, bifurcated and elongated laths of albite and chlorite and further, intersertal-ophiolite ones. Sometimes large pillows are of relict-ophitic structure turning into lepidoblastic. The rocks are rich in amygdaloid cavities, filled with epidote, chlorite and carbonate.

The second sheet, as a whole is massive and only in the sole (0.20-0.80 m) there occur brecciated formations – tuff lavas. Greyish dark grey breccias of aleuropelitic structure represent cement-recrystallized glass of basaltic composition. The massive part of the body is light green, has relict intersertal-ophitic structure, primary minerals being preserved only as primary contours. Plagioclase has turned into saussurite-carbonate aggregate and pyroxene – into uralite-chloritic laths. The body is concordant in laminated aleuropelitic member. In the sole of the sheet the shales are of lighter (10-12 cm) colour at the roof they are fresh.

The upper, third body of the basaltic sheet is dark green and has pillow structure. According to textural-structural indices, mineral composition and the character of the subsequent changes the rocks are analogous to the upper part of the lowermost, first sheet. The basaltic sheets, evidenced in the Lamazuri river bed, are uninterruptedly observed on the left slope too: the first one – at 1250m, the second – at 250m the third – at 260m and they gradually pinch-out. On the right slope all of them are continuously observed at 130-150 m up to the divide of the rivers Lamazuri and Kvachadala and, further, along the left slope of the latter – as a fragmental explosure: the first sheet at 1250m, the second – at 1500 and the third – at 1650m.

The structure, texture and mineral composition of the rocks are more or less preserved all over the strike. The exposure of the described bodies in the considered segment exceeds 500 m (vertically).

So, the summary thickness of the sheets in the Kvachadala segment makes up 70-80m, being observed along the strike over 3 km and more.

Together with the bedrocks of the above described bodies, in the considered segment, their detrital-clumpy accumulations are observed. The dimensions of the lumps reach 5X7 and more. The author has delineated has seven separate accumulations: two of them along the left slope of the Lamazuri river bed, five along the left slope of the river Kvachadala. The delineated territory is about 370 000 m 2 depth of accumulations 0.2-2.5m.

According to the results of statistic processing of the data, lava breccias make up 35% of the whole volume of the volcanic formations, basalts with pillow texture 25%, massive lavas 20%, tuff lavas 10% and volcanites, intensively saturated with quartz, quartz-epidote, carbonate, epidote-ziosite veins of various orientation and their lenticular accumulations, 10%.

The chromatic gamma of the rocks varies from greenish-grey to bluish-green. The same colour is more or less preserved within analogous textural varieties. So, in rocks with massive texture greyish-green predominates, lava breccias are generally light green with darker fragments. The basic texture of tuff breccias is light green, fragments are light grey or greenish-grey. The colour of veins and lenticular accumulations, penetrating into the rocks, varies in accordance with composition. Carbonate veins are colourless, quartz-milky white, prehnite-carbonate-light green and epidote-zoisite-bluish green.

In spite of variegation of coloration and textural-structural variety, the rocks of the complex have nearly

Table 1

Results of Chemical Analyses of the Late Pliensbakhian-Early Toarcian Volcanic Rocks

Order N	SiO_2	TiO_2	Al_2O_3	FeO	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	P_2O_5	Moisture	Heating pass	Total	Rock name	Place of taking
Kvachadala-Lamazuri basin																
1	47.38	0.54	12.58	6.15	3.70	8.87	0.14	7.62	4.00	0.25	0.03	0.04	8.52	99.82	lava breccia	riv. Lamazuri
2	50.40	0.44	14.28	6.75	3.29	6.80	0.16	11.36	3.82	0.25	0.03	0.04	2.54	100.14	--	--
3	47.42	0.50	15.82	6.53	3.60	6.93	0.14	9.96	4.15	0.25	0.03	0.10	4.20	-	--	--
4	48.38	0.87	16.63	6.66	2.64	7.53	0.10	7.88	4.30	-	0.02	0.26	3.82	99.09	pillow lava cement	--
5	45.15	0.82	16.57	6.04	5.05	10.04	0.15	5.63	5.00	0.50	0.05	0.57	4.47	100.34	--	--
6	48.62	0.90	17.04	7.10	1.69	7.09	0.10	6.19	4.80	0.30	0.15	0.06	5.12	99.26	pillow core	--
7	47.72	0.60	16.65	5.94	2.57	7.13	0.07	10.36	4.00	0.25	0.32	2.13	2.25	99.99	--	--
8	44.95	0.36	14.80	6.66	7.60	10.12	0.28	4.28	3.30	-	0.03	1.07	6.70	99.36	crust of altered pillow	riv. Kvachadala
9	44.81	0.94	16.72	7.82	0.77	5.96	0.07	10.00	4.75	-	-	0.47	7.93	100.20	crust of altered pillow	--
10	44.05	0.36	13.26	7.68	1.90	8.40	0.10	11.00	4.75	1.30	0.03	0.40	6.00	99.59	core of altered pillow	--
11	48.95	0.25	14.45	10.29	2.65	7.25	0.14	9.02	4.00	0.30	0.07	0.45	2.80	100.62	cryptocrystalline lava	--
12	46.82	0.38	14.05	8.40	3.60	8.08	0.12	7.18	4.30	0.40	0.06	1.52	5.63	100.54	--	--
13	46.40	0.17	12.58	8.44	3.35	6.71	0.14	12.66	4.85	0.35	0.03	0.40	3.60	99.68	holocrystalline lava	--
14	47.16	0.24	13.66	9.36	3.84	7.34	0.016	10.52	4.45	0.25	0.03	0.30	2.65	99.96	--	--
Stori-Mazimchai Interfluve																
15	51.09	0.67	16.44	7.27	2.01	6.03	0.12	6.78	4.22	-	0.17	1.26	4.05	100.11	pillow core	riv.Shromiskhevi
16	51.97	1.02	13.57	5.92	2.92	6.89	0.14	6.81	4.60	0.50	0.36	1.14	3.44	99.12	holocrystalline lava	riv. Lagodekhiskhevi
17	47.20	0.50	14.86	7.52	4.36	8.14	0.12	8.12	4.12	0.25	0.14	0.92	4.45	100.70	cryptocrystalline lava	--
18	45.15	0.82	16.57	5.04	6.05	10.04	0.15	5.63	5.00	0.50	0.02	0.57	4.47	100.01	altered lava breccia	riv. Stori
19	50.11	1.20	14.54	6.12	3.31	5.23	0.20	10.03	4.20	0.50	0.31	0.33	4.33	100.31	cryptocrystalline lava	--
20	48.38	0.87	16.63	6.66	1.64	7.53	0.10	7.88	4.30	-	0.12	0.76	3.82	99.69	holocrystalline lava	--
Khevsureti																
21	53.02	0.94	16.00	8.87	1.05	3.07	0.07	3.07	7.70	0.30	0.19	0.34	3.89	100.02	variolite	riv Tsertsvlova nistskali
22	49.01	0.90	14.42	8.97	1.75	9.36	0.24	7.30	4.00	0.30	0.09	0.74	2.88	99.69	diabase	--
23	46.92	0.90	14.54	8.35	2.88	9.68	0.24	5.60	4.20	0.30	0.02	0.55	5.49	99.67	diabase	--
Mountainous Abkhazeti																
24	52.52	1.80	15.30	7.54	2.42	7.64	0.18	1.26	4.50	-	0.20	0.60	5.98	99.97	pillow lava	riv. Ashimkhur
25	51.31	1.38	13.94	6.46	2.53	8.64	0.14	5.00	4.90	-	0.15	0.60	5.26	99.99	--	
26	50.11	1.63	13.60	8.40	1.78	6.56	0.14	7.74	4.50	0.20	0.17	0.40	4.38	99.61	--	

Table 2

Physico-mechanical properties of volcanogenic rocks of the Kvachadala deposit

№	Number of rocks	Names of the rocks	Average density kg/m^3	Water absorption%	Specific weight gr/cm	Porosity%	Attrition gr/cm^2	Strtength at compression kg/cm^2				Sterngth loss after the frost resistance cycle	Note
								Dry	Water saturated	After freezing	Softening		
1	2	3	4	5	6	7	8	9	10	11	12	13	
1	1	Tuff breccia	2900	0.36	3.15	0.95	0.12	735	626	570	0.85	9	Weakly weathered
2	2	Lava breccia	2837	0.38	3.06	0.87	0.38	742	594	575	0.80	3	
3	3	,,---------- ‘	2932	0.35	2.97	0.91	0.36	806	687	600	0.85	13	
4	4	,,---------- ‘	2950	0.12	3.00	1.06	0.21	1100	818	705	0.80	14	
5	5	Lava of pillow structure	2808	0.17	3.03	0.84	0.37	1056	1035	1000	0.98	4	
6	6	,,---------- ‘	2890	0.27	2.89	1.01	0.41	1090	1050	1030	0.96	2	Weathered
7	7	Massive besalt	2820	0.25	2.97	0.80	0.28	562	618	565	0.92	11	
8		,,---------- ‘	2940	0.17	2.99	0.69	0.27	876	790	770	0.90	3	
9	9	Diabase	2998	0.18	2.98	0.93	0.20	836	803	775	0.96	5	
10	10	Lava of pillow structure	2930	0.16	2.97	1.03	0.12	822	784	705	0.83	7	
		Total average volume	2900	0.24	3.00	0.91	0.26	868	771	719	0.88	7	

the same chemical (Table 1) and mineral compositions and physical-mechanical and technologic properties.

The main primary rock forming minerals of the complex are basic plagioclase and pyroxene. Comparatively fresher ones are found only in holocrystalline varieties of the complex. In the other textural varieties the principal minerals rarely preserve their primary appearance. Plagioclases are albitizated or turned into saussurites. Pyroxene turns into chlorite and lamellar or needle actinolite rarely develops over it. Volcanic glass has turned into epidote- ziosite, epidote-carbonate or albite-chlorite-carbonate granular scarry mass.

All the investigated principal kinds of volcanites satisfy the requirements of the State Standard Committee 9679-84 according to the reduced (111 samp.) and broadened (10 samp.) program. The results of investigations according to the broadened program are given in Table 2.

As the analyses of the received results show, all the investigated varieties of rocks completely meet the requirements set to ornamental stones. They belong to the group of more resistant rocks and thus may be used for lining, facing and floor and stairs boarding where the maximal volume of traffic is 100 men per hour or even more. As for radioactivity, the rocks belong to the first class and are allowed to be used in great quantity.

The reserves of C_1+C_2 category and the predicted resources of the deposit have been calculated. On the basis of the author’s recommendation, in 2007 the Ministry of Natural Resources and Protection of Environment gave a licence for commercial mining of the Kvachadala deposit.

Thus, multi-year investigations of Late-Pliensbachian-Early Toarcian basaltoids from the shaly zone of the Southern Slope of the Greater Caucasus, have demonstrated that sheets at full length preserve sufficiently stable homogeneity of chemical composition and textural-structural properties as well as of mineral composition and character of variation.

Study of the volcanogenic complex, revealed at the Kvachadala deposit, proved the availability of high-quality raw material for manufacturing blocks and tiles with various surface texture for lining and facing walls of buildings and structures.

Considering the results, the author assumes that there may exist analogous deposits at full length of outcrops of the Southern Slope of the Greater Caucasus from the headwaters of the river Bzybi to Trans-Alazanian Kakheti inclusive. The author recommends carrying out special geological investigations in this direction.

ვულკანოლოგია

კავკასიონის სამხრეთი ფერდის გვიანპლიოცენ-ადრეტოარსული ვულკანური კომპლექსი, როგორც მოსაპირკეთებელი ქვის ფილების ბუნებრივი ნედლეული (ქვაჩადალის საბადო)

კ. აქიმიძე

ი. ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი

(წარმოდგენილია აკადემიის წევრის დ.შენგელიას მიერ)

კავკასიონის სამხრეთი ფერდის ფიქლების სერიაში ვულკანიზმის სამი დონეა ცნობილი. აქ ყველაზე ფართო გავრცელებით სარგებლობს გვიანპლიოცენ-ადრეტოარსული სუბტუტე ბაზალტები, რომლებიც ცალკეული გამოსავლების სახით დაფიქსირებულია საქართველოს მთელ ტერიტორიაზე, მდინარე ბზიფის სათავეებიდან დაწყებული, ვიდრე საქართველო-აზერბაიჯანის საზღვრამდე. სტატიაში მოყვანილია ავტორის მიერ მდ. ალაზნის სათავეებში – ქვაჩადალის უბანზე გამოვლენილი ანალოგიური ბაზალტოიდების შესწავლის მონაცემები, რომლის მიხედვითაც დადგენილია, რომ ეს კომპლექსი სრულად პასუხობს ყველა ტექნიკურ და ტექნოლოგიურ მოთხოვნებს, ხასიათდება ლამაზი გარეგნული ფაქტურით და წარმოადგენს მოსაპირკეთებელი ქვის ფილების დასამზადებელ შესანიშნავ ნედლეულს. ამავე დროს რადგან ბაზალტური კომპლექსი მისი გავრცელების ფარგლებში ხასიათდება დიდი ერთგვაროვნებით, ავტორი ამ კომპლექსს პერსპექტიულად მიიჩნევს მოსაპირკეთებელი ქვის ბლოკებისა და ფილების მისაღები ნედლეულის თვალსაზრისით და მათი ამ მიმართულებით შესწავლის რეკომენდაციას იძლევა.

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