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Some geological and petrological characteristics of the Eocene trachybasalt-trachyandesite-basalt-phonolite formation of the Talysh zone (Azerbaijan)

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Abstract. This article discusses the stages of crystallization of the Eocene trachybasalt-trachyandesitebasalt-phonolith formation of the Talysh zone. Determination of the composition of the primary magma, evolution and melting fraction of the initial melt of the Eocene volcanism of the Talysh zone within Azerbaijan. Eocene volcanism of the trachybasalt-trachyandesitebasalt-phonolith formation of the Talysh zone. Petrographic, petrochemical, geochemical studies of rocks, typomorphic features of mineral paragenesis, chemical composition of rocks were carried out by X-ray spectral and X-ray fluorescence analysis. The analyzes of the conducted studies show that the Talysh zone was formed in the Eocene time. Stages of evolution of the original magma and typomorphic features of mineral parageneses have been established. The distributions of microelements in mineral parageneses, which are direct participants in the crystallization processes that took place in intermediate chambers at different depths, have been studied. At present, the question arises of the need to clarify the typomorphic features of igneous complexes, as factors that determine the geodynamic regimes of their formation, and to determine the potential ore content. The petrographic and petrochemical characteristics of the volcanic rocks are given. It was found that if the process of differentiation in the Early-Middle Eocene was more distinct with the initial formation of more magnesian rock varieties (picrite-trachybasalts), and subsequently more ferruginous ones (trachyandesites and trachyandesitebasalts), then such accumulation of iron is not observed in porphyritic trachyandesites. This petrochemical feature is obviously associated with the duration of the break in volcanism, caused by the formation of a thick sedimentary-tuffaceous stratum, accompanied by the initiation and manifestation of an intermediate chamber of medium composition. Volcanism in the Late Eocene was undifferentiated and was not accompanied by the formation of medium differences. The appearance in the late Eocene of leucite phonolites, which represent an alkaline branch, and the absence of transitional varieties indicate the autonomous development of vitrobasalts and leucite phonolites. It is concluded that from the early phases of the manifestation of Eocene volcanism to the later phases, the change in the material composition along the lateral is expressed in the manifestation of more alkaline facies with a significant predominance of K over Na and with a greater correspondence to the differentials of the shoshonite series.

Key words: Talysh zone, Eocene volcanism, geodynamic regimes, igneous complexes, mineral assemblages.

Деякі геолого-петрологічні характеристики еоценової трахібазальт-трахіандезібазальт-фонолітової формації Талиської зони (Азербайджан)

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Анотація. У цій статті розглядаються етапи кристалізації еоценової трахібазальт-трахіандезібазальт-фонолітової формації Талиської зони. Визначено склад первинної магми, еволюцію та особливості плавлення вихідного розплаву еоценового вулканізму Талиської зони в межах Азербайджану. Розглянутий еоценовий вулканізм трахібазальт-трахіандезібазальт-фонолітової формації Талиської зони. Проведені петрографічні, петрохімічні, геохімічні дослідження порід, втанослені типоморфні особливості мінеральних парагенезисів. Хімічний склад порід проводився методом рентгеноспектрального та рентгенофлуоресцентного аналізів. Аналізи проведених досліджень показують, що талиська зона утворилася в еоценовий час. Встановлено етапи еволюції вихідної магми та типоморфні особливості мінеральних парагенезів. Вивчено розподіл мікроелементів у мінеральних парагенезисах, які є безпосередніми учасниками кристалізаційних процесів, що відбувалися в різноглибинних проміжних осередках. Нині виникає питання щодо необхідності з'ясування типоморфних особливостей магматичних комплексів, як чинників, що визначають геодинамічні режими формування, та питання необхідності з'ясування потенційної рудоносності. Дано петрографічну та петрохімічну характеристику вулканітів. З'ясовано, що якщо процес диференціації в ранньо-середньому еоцені носив більш чіткий характер з початковим утворенням більш магнезіальних різниць порід (пікріт-трахібазальти), а в подальшому – більш залізистих (трахіандезити і трахіандезібазальти), то в порфірових трахіандезитах подібного на спостерігається. Ця петрохімічна особливість, очевидно, пов'язана з тривалістю перерви у вулканізмі, викликаного формуванням потужної осадово-туфогенної товщі, що супроводжувалася закладенням та проявом проміжного осередку магми середнього складу. Вулканізм у пізньому еоцені був недиференційованим і супроводжувався утворенням середніх різновидів. Поява в пізньому еоцені лейцитових фонолітів, що являють собою лужну гілку та відсутність перехідних різниць, свідчать про автономний розвиток вітробазальтів та лейцитових фонолітів. Зроблено висновок, що від ранніх фаз прояву еоценового вулканізму до пізніх змінення речовинного складу по латералі виражено у прояві більш лужних фацій з істотною перевагою K над Na та з більшою відповідністю диферецiатам шошонітової серії.

Ключові слова: Талиська зона, еоценовий вулканізм, геодинамічні режими, магматичні комплекси, мінеральні парагенези.

Introduction.

The Talysh zone, comprising southwest part of Azerbaijan and northwest of the Islamic Republic of Iran, is located on the west coast of the Caspian Sea. From the downstream of the Sefid-Rud River, this zone stretches over 400 km northwest to the Arax River. It it is bordered by the Iranian Qara-dağ mountain in the western direction, and by the Pre-Talysh deep-seated fault in the east.

The geological structure of the region, especially its petrologic specifics, has been studied by many scientists (Azizbekova et al., 1979; Mamedov, 1999; Karimov 2007). In their studies, the Iranian part of this zone has been characterized to various extents. In most cases, the researchers, based on geological analysis, assume that the Talysh zone is likely to be the southeast continuation of the Lesser Caucasus, while the northwest is the continuation of the Alborz folded belt. According to the most recent data, the Talysh zone is separated by the Palmyra-Apsheronsk fault from the Lesser Caucasus, and by the diagonal Bogrov Dag shift in the southwest, i.e. Taromsk zone (Khain, 1975; Pilchin and Eppelbaum, 2020) (Fig. 1). According to the data of those authors, in the south-eastern direction, the Talysh folded zone fuses with the Alborz folded structure (Geology of Azerbaijan, 2005; Aliyev, et. al., 2009).

During the **tectonic** development of the Talysh folded zone, the region has been segmented into separate blocks by disjunctive dislocations, which indicate the intensity of tectonic movements (Fig. 2). Those faults were mainly magma-driving. The indicated dislocation structures were confirmed by contemporary geophysical studies (according to GPS-observations and others) and three types of dislocations were determined: reverse faults, strike-slip and dip-slip faults (Geology of Azerbaijan, 2001; Kazymova and Kazymov, 2020).

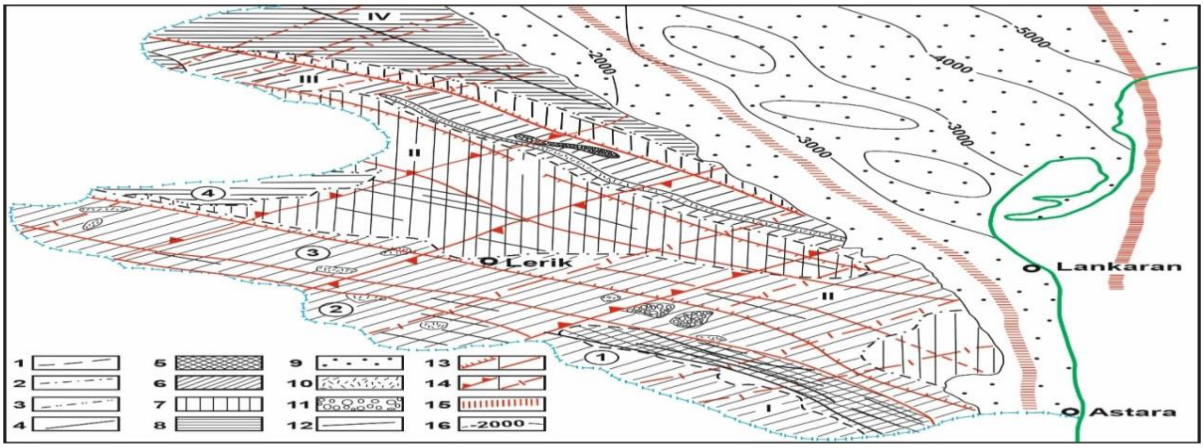


Fig. 1. Structural-formational map of the Talysh zone (Azizbekov, et. al., 1979)

1–4 – boundaries of structural levels along the base: 1 – Early Eocene; 2 – early Oligocene; 3 – Middle Miocene; 4 – Pleistocene; 5–9 – formations and complexes: 5 – clastic-tuffaceous of Upper Cretaceous–Paleocene; 6 – volcanogenic (alkaline basaltoid) of Eocene; 7 – marine molasse of the Oligocene–Early Miocene; 8 – lagoon-marine of Middle Miocene; 9 – continental-marine Quarternary; 10, 11 – subvolcanic intrusions: 10 – Eocene; 11 – subalkaline ultrabasic; 12 – axis of fold; 13 – faults at the boundaries of tectonic zones; 14 – transverse faults (flexures); 15 – buried deep faults according to geophysical data; 16 – isolines by the buried surface of the Upper Cretaceous

Transversal fault structures to a sufficient degree complicate the longitudinal folded structures, such as Astara, Burovar and other. They are represented by the transversal structures Astara, *Pilyachay*-Qosmolyan, Kivi-Xalxal faults, and also Masally elevation. We can conclude that during the Early Eocene epoch, the considered zone was intensively fragmented and segmented, resulting into formation of transversal faults, which contain and border grabens and horsts. Within the area under consideration, structural-formational zones are separated by these fault structures, many of which are of a regional nature.

For the formation of the Talysh folded zone, represented by trachibasalt-trachiandesibasalt-phonolite formation (Karimov, 2007), the compositions of initial magmas and share of their melt have been determined. Based on those data, it is possible to conduct a detailed analysis of physical-chemical conditions of formation and geodynamic regimes of magmatic complexes, as well as determine the evolution of volcanism occurring within their borders.

Petrological and perographic aspects of volcanic formations of the Talysh zone were the subjects of studies by S. A. Azizbekov, M. N. Mamedov, G. D. Babaeva, V. M. Karimov (Azizbekov et. al., 1979; Mamedov, 1999; Karimov, 2007).

Analysis of spatial positions and facies specifics of Eocene volcanogenic, sedimentary and volcanogenic-sedimentary formations revealed that they are concentrated in the Talysh zone, where volcanism of subalkaline and alkaline main compounds manifested in the Early Eocene (Azizbekov, et. al., 1971).

Analysis of the most recent studies and publications reveal that the Talysh Eocene magmatic complexes were studied in geological and geological-petrological aspects, and the issues of the stages of crystallization and indicatory values of mineral parageneses have not been determined completely. So far, the conditions of generation of subalkaline and alkaline basalt series have not been studied completely, as mentioned in the article (Yoder and Tilley, 1962; Karimov, 2020).

Analysis of the behaviour of rare-earth elements in the composition of rocks of subalkaline and alkaline complexes of the Talysh revealed that the substrate from which the subalkaline olivine-basalt melt had melted has been to a certain degree enriched by non-coherent elements and had been initially subjected to metasomatic transformation (Karimov, 2020; Mamedov, et. al., 2007).

In order to study the trachybasalt-trachyandesite-basalt-phonolith formation of the Eocene age of the Talysh zone, it seems necessary to study the petrogeochemical features and indicator values of igneous complexes, which make it possible to determine the development of magmatism from magma generation to the evolution of the original melt under the conditions of the earth's crust, as well as to reflect the specifics of their manifestation (Azizbekov, et al. al., 1979).

Methods.

The paper presents new analytic data on the composition of rocks and minerals of trachibasalt-trachiandesibasalt-phonolite formation of the Talysh zone, based on the author's materials (Karimov, 2007). The analysis of rocks and part of clinopyroxenes was performed at the chemical laboratory Uralgeologia of the Ministry of Geology of the Russian Federation (Yekaterinburg). Compositions of clinopyroxenes and melt inclusions they contained were determined using microsound analysis technique (Camebax-micro) at corresponding laboratories of the United Institute of Mineralogy of the Russian Academy of Sciences (Novosibirsk). Given that, magmatic complexes were distinguished, based on the share of melt and composition of the initial magmas (Mamedov, et. al., 2017).

Some of the analyzes on the content of rare and rare earth elements are borrowed from the work of Vincent et al. (2005), and part of it was made by the author using the X-ray fluorescence method.

The materials on distribution of rare and rare-earth elements in various types of rocks, as well as study of their other geochemical and petrologic characteristics allow analysis of some aspects of processes of genesis, evolution and crystallization of deep magmatic melts using well-known models (Imamverdiyev, 2003; Imamverdiyev et. al., 2020).

In this aspect, the study of geochemical characteristics of the mantle and crust sources of volcanism is quite relevant (Imamverdiyev, et. al., 2018, 2021). Therefore, the study of the Talysh Eocene volcanism is of theoretical and practical interest.

Discussion of the results.

Paleozoic, Mesozoic and Cenozoic magmatic, metamorphic, sedimentary and volcanogenic-sedimentary complexes participate in the geological structure of the Talysh zone. Volcanogenic and volcanogenic-sedimentary formations formed during the Eocene stage of sediment accumulation and volcanism.

Within the Eocene trachybasalt-trachyandesite-basalt-phonolith formation, there are distinguished several layers, which correspond to certain phases of Eocene volcanism: layer of tuffs of trachiandesibasalts, trachibasalts, absarokites and leucite tephrites, sedimentary-tuffogenic layer, layer of alkaline basalts, flyshoid sedimentary-tuffogenic layer, layer of analcime trachiandesibasalts, tuffogenic-sedimentary layer, layer of subalkaline of vitrobasalts and trachibasalts, epileucite phonolites, trachiandesibasalts, subalkaline basalts and phonolites (Geology of Azerbaijan, 2005; Azizbekov, et. al., 1979).

The Eocene trachibasalt-trachiandesibasalt-phonolite formation has two complexes. 1. *Absarokite– shoshonite – alkaline basalt* (early-middle Eocene) complex (~ 3000 m) is most developed in the central part of the Astara anticlinorium, in the Qosmalyan depression, and also on its northeast pit side. 2. *Trachiandesibasalt – phonolite* (late Eocene) complex (~1500 m) is spread to the northwest, in the Duman depression (Karimov, 2007).

Petrographic characteristics. In the composition of the early-middle Eocene volcanogenic complex, there are mostly observed trachibasalts, olivine-leucite tephrites, trachidolerites (essexites), trachiandesibasalts, plagioporphyry trachiandesites, leucite trachiandesites, trachytes and others.

Trachybasalts are porphyiry rocks with pilotaxite and intersertal main mass, often with palagonite segregations, almond-shaped. Trachydolerites and essexites (55 M years) (Azizbekov et. al., 1979) make up the subvolcanic bodies, which near the effusive bodies differ mineralogically by microdolerite and ophitic structures, with potassium sodium feldspar and analcime in interstitices. Olivine-leucite tephrites (52 M years) are melanocratic porphyritic rocks with ocellar-intersertal main mass. Leucites in the main mass have irregular shape and are often concentrated around the contour of pyroxene impregnations. Trachyandesibasalts are autoclastic lavas with breccias texture. They are characteristic of porphyroclastic structure with pilotaxite and hyalopilitic main mass. Plagioporphyritic trachyasndesites (42 M years) are light grey megaplagioporphyritic rocks with hyalinic, vitrophyric and pilotaxitic main mass. Trachytes are leucocratic rocks with trachytic structure.

The compound of the late Eocene complex was observed to have subalkaline vitrobasalts, trachydolerites (essexites) and leucitic phonolites.

Subalkaline vitrobasalts (trachybasalts) (42±2 M years) are melanocratic porphyritic rocks with vitroporphyritic and hyalopilitic main mass. Trachydolerites and essexites of subvolcanoes are porphyritic and porphyry-like rocks with intersertal-dolerite and ophitic structures of the main mass. Leucite phonolites (30-32 M years) are porphyritic rocks with trachytoid main mass. Leucite in impregnations occurs in hexagonal and octagonal sections, is surrounded by microlites of the main mass. In some individuals, very small inclusions were found with characteristic zonal positions. Often, 2-3 individuals grow together. Leucite in the main mass forms ocelli and rarer hexagonal crystals (0.03…0.07 mm). According to F. Y. Levinson-Lessing, they form because of fast solidification of the melt.

Petrochemical characteristics. Petrochemical characteristics of volcanogenic formation of the Talysh zone is based on over 100 silicate analyses, including 60 performed on the author's material (Table 1) (Table presents only 30 analyses).

On the classification diagram SiO_2-Na_2O+K_2O (Fig. 2), figurative points of the compounds of rock formation are mostly concentrated in the field of alkaline and subalkaline series. At the same time, by level of alkalinity, the dominant position is held by alkaline basaltoids of the first complex. The rocks of the second complex are mainly located in the field of the subalkaline series. Leucite phonolites of this complex are characterized by heightened content of alkaline oxides, and points of composition of those rocks on the classification diagram SiO_2-Na_2O+K_2O are concentrated in the field of alkaline series.

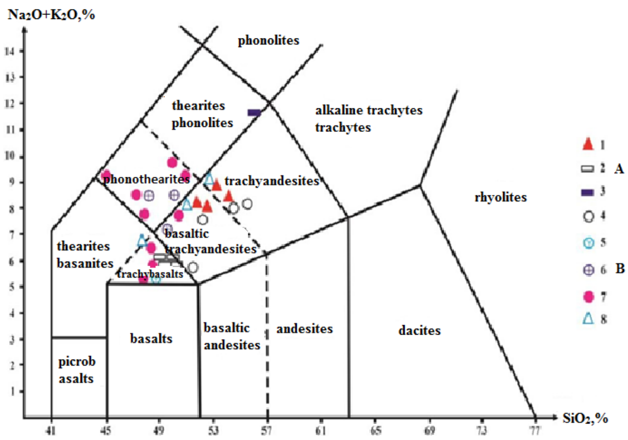


Fig. 2. The position of the figurative points of the composition of the rocks of the trachybasalt-trachyandesitebasalt-phonolite formation of the Talysh zone on the SiO_2-Na_2O+K_2O classification diagram. **A** – Absarokite-shosonite-alkaline basalt complex: 1 – analcimed sanidine trachybasalt tuffs; 2 – clinopyroxenes and subalkaline gabbroids; 3 – analcime, biotite and hornblendite trachybasalts; 4 – absorokites, shoshonites, tephrites, leucite trachybasalts, trachydolerites, essexites; 5 – alkaline basaltoids. **B** – Trachiandesibasalt-phonolite complex: 6 – olivine leucite, analcime essexites; 7 – subalkaline basalts, trachybasalts, trachydolerites, essexites; 8 – leucite phonolites

Study of petrochemical peculiarities of individual layers of the formation demonstrate that content of the rock-forming components changes from one layer to another, reflecting the pattern of differentiation of

Table 1. Chemical analysis of rocks trachybasalt-trachyandesite basalt-phonolite formation of the Talysh zone.

Comp. / № an.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	ldp	e
1	52.40	0.16	23.26	2.16	1.75	0.36	2.46	4.21	5.11	2.34	0.21	5.66	100.08
2	51.46	0.37	22.33	3.36	2.75	0.16	3.75	6.32	3.34	2.23	0.16	4.25	99.50
3	54.76	0.10	19.36	1.86	1.75	0.11	1.84	6.75	3.46	4.57	0.26	4.68	99.50
4	55.48	0.06	20.21	1.38	2.16	0.12	1.76	5.47	3.75	4.82	0.38	4.61	100.20
5	48.81	1.19	14.71	2.10	6.80	0.14	7.67	9.21	3.15	2.23	0.52	3.34	99.87
6	42.0	1.82	9.61	0.09	12.0	0.17	12.65	19.36	0.62	0.24	0.29	0.64	99.44
7	49.74	0.94	19.43	2.51	4.73	0.16	3.66	8.84	4.75	2.36	0.28	2.42	99.82
8	48.49	0.70	17.20	4.67	3.36	0.16	4.36	9.01	4.51	3.94	0.45	3.54	100.39
9	50.31	1.10	17.36	4.63	3.26	0.18	3.21	9.31	4.23	4.26	0.37	1.46	99.68
10	47.50	0.91	13.90	5.19	3.80	0.17	5.92	9.50	3.46	5.12	0.31	3.74	99.52
11	45.33	0.65	16.32	4.23	4.83	0.21	6.38	8.48	5.82	3.42	0.25	3.78	99.70
12	50.98	0.91	14.70	2.41	6.78	0.17	5.27	4.85	0.60	8.80	0.43	3.75	99.25
13	50.21	0.56	16.46	3.36	4.23	0.23	4.32	6.73	4.24	5.43	0.25	3.28	99.30
14	48.20	1.11	15.46	3.23	6.16	0.17	7.33	7.63	3.74	3.86	0.33	2.73	99.95
15	48.34	0.68	12.54	3.01	6.39	0.15	12.31	7.27	2.85	3.55	0.44	2.67	100.27
16	48.83	0.97	17.25	4.29	5.57	0.15	7.28	9.38	1.90	3.88	0.40	2.56	100.46
17	48.03	0.96	16.66	2.05	8.31	0.11	6.48	9.03	2.48	2.57	0.39	2.73	99.80
18	50.59	0.87	16.40	4.27	3.91	0.16	3.90	7.82	2.85	4.94	0.40	3.10	99.30
19	47.79	1.30	16.35	7.94	3.36	0.16	3.89	9.11	3.52	2.94	0.69	2.08	99.13
20	52.26	0.88	19.37	3.38	2.12	0.17	2.13	6.25	3.20	5.60	0.28	3.86	99.50
21	50.99	0.88	18.03	5.83	3.30	0.21	2.09	9.31	4.55	3.37	0.23	1.80	100.50
22	54.20	0.69	19.25	2.79	2.73	0.12	1.75	7.50	4.21	4.07	0.54	2.23	100.08
23	53.20	0.84	17.18	2.98	2.74	0.13	2.93	4.83	5.17	3.48	0.65	4.64	99.37
24	52.60	0.93	18.23	3.47	2.71	0.71	3.13	4.52	3.81	4.01	0.83	4.15	99.10
25	51.68	1.18	19.11	3.46	3.92	0.11	4.10	5.27	3.08	5.01	0.78	2.85	100.55
26	50.87	0.98	16.22	4.26	5.19	0.18	7.43	8.19	2.82	2.82	0.25	0.38	99.59
27	49.30	0.76	18.80	3.90	5.01	0.22	5.10	8.50	3.04	2.72	0.26	1.75	99.38
28	49.60	1.44	16.01	4.59	5.86	0.16	4.41	9.41	2.81	3.31	0.18	1.68	100.06
29	49.64	1.12	16.25	3.82	6.38	0.17	6.30	7.55	2.85	3.22	0.44	1.55	99.79
30	56.19	0.85	16.98	3.25	2.76	0.09	2.51	1.69	1.93	9.60	0.55	2.60	99.0

Note: 1–4 – sanidine tuffs of trachyandesibasalt, 5 – clinopyroxenite, 6 – subalkalic gabbro, 7–9 – analcite-biotite and hornblend trachybasalts, 10 – absarokite, 11 – shoshonite, 12 – leucitic trachybasalt, 13, 14 – tephrites, 15, 16 – trachydolerites, 17, 18– essexites, 19–21 – alkaline basaltoids, 22, 23 – analcite trachyandesibasalt, 24, 25 – latite, 26 – subalkaline basalt, 27 – trachybasalt, 28 – trachydolerite, 29 – essexite, 30 – epileucitic phonolite.

the initial subalkaline basalt magma at different levels of the Earth's crust.

According to petrochemical composition (Table 1), the rocks of the analyzed formation correspond to the differentiates of subalkaline and alkaline series (Fig. 2). Likewise, the rocks of the formation are characteristic of normative nepheline, leucite, olivine, clinopyroxene (Mamedov, et. al., 2017).

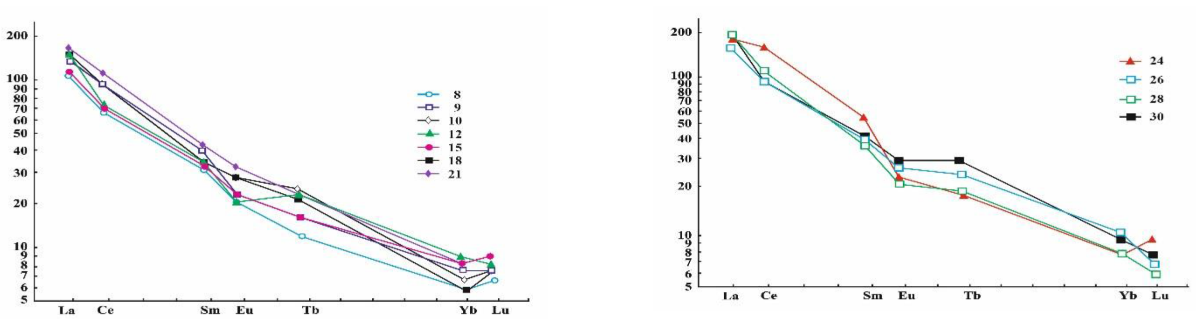
General petrochemical features of volcanogenic formations are determined by deficiency of siliceous earth, low concentration of TiO_2, high alkalinity in K/Na>1 and OL-Ne association. In the evolution of the compositions, we can see gradual decrease in iron, magnesium, and calcium, whereas as the siliceous earth increased, alkalinity and alumina were increasing, with dominance in the final potassium phases. At the same time, in the composition of rocks, the concentrations of anorthoclases, and sanidines increase, leucite appears, and the content of titanium in dark-coloured minerals increases with occurrence in leucitic phonolites and gabbro-syenite ilmenite and sphene.

The initial melt was initially enriched in alkaline, subalkaline (K, Rb, Na), and alkaline earth (Sr, Ba) elements (Karimov, 2007). This is confirmed by presence of megacrystals of phlogopite in rocks – tephrites, trachybasalts, analcimites, and crystallization of initial melt in intermediate and deep magmatic sites in an oxidative environment. This is also evidenced by presence of phlogopite and highly-potassium melt microinclusions, confined to impregnations of olivine and clinopyroxene.

Table 2. Microelement composition of rocks trachybasalt-trachyandesite basalt-phonolite formation of the Talysh zone.

Comp. . № an	Ti	V	Ni	Co	Cr	Sc	Ba	Sr	Rb	Li	Nb	Ta	Y	Hf	Th
1	959	110	25	12	15	18	550	400	30	20	6	0.21	15	1.7	1.6
2	2218	150	30	25	30	15	560	420	60	25	4	0.26	16	1.3	1.8
3	560	60	10	7	6	20	1200	260	120	10	10	0.28	6	2.0	2.0
4	360	30	8	4	4	25	1150	270	150	12	12	0.23	4	2.3	2.5
5	7134	200	100	30	350	30	360	850	10	15	6	-	3	2.1	0.4
6	1091	350	160	35	700	35	370	900	8	10	4	-	4	2.2	0.6
7	5695	360	50	30	140	20	560	850	30	10	4	0.35	12	3.0	1.4
8	4197	300	45	34	100	25	840	900	60	12	6	0.24	8	3.2	1.2
9	6594	360	60	35	150	23	860	960	80	8	3	0.22	4	3.4	1.3
10	5455	280	75	42	130	20	1200	700	140	10	2	0.15	6	3.6	1.6
11	3897	240	40	20	130	21	1000	700	110	11	3	0.16	3	3.1	1.2
12	5455	310	40	25	120	20	1600	350	280	12	2	0.17	16	3.0	1.1
13	3357	150	20	10	60	20	1040	600	130	12	1	0.21	2	3.2	1.4
14	6654	160	45	36	95	21	1100	610	135	15	4	0.23	4	3.3	1.2
15	4071	350	250	60	270	20	1000	750	120	25	3	0.16	8	2.6	1.3
16	5815	320	200	50	240	18	960	650	100	24	2	0.15	10	2.7	1.2
17	5755	175	130	30	300	30	950	720	100	12	12	0.76	12	2.0	1.7
18	5716	176	120	60	250	27	1100	780	120	11	14	0.64	16	2.5	1.6
19	7794	120	30	20	130	24	500	630	75	12	10	0.52	12	1.6	1.3
20	5276	70	42	20	62	10	960	460	116	10	10	0.11	11	1.2	1.2
21	5276	75	36	24	35	16	700	600	70	8	9	0.12	14	1.1	1.0
22	4136	100	42	31	35	20	1100	720	100	8	6	0.16	12	1.3	1.2
23	5036	95	46	34	38	21	860	820	90	10	7	0.15	14	1.2	1.5
24	5575	92	40	35	39	20	980	860	95	6	6	0.16	1.7	1.4	1.2
25	7074	196	60	40	94	30	1000	840	100	12	7	0.11	1.2	1.1	1.0
26	5875	200	66	42	92	35	960	850	80	14	6	0.11	0.8	1.3	1.1
27	4556	166	75	46	96	42	1100	870	110	16	7	0.12	1.1	1.4	1.0
28	5633	176	80	50	156	46	1120	900	120	11	5	0.16	1.4	1.2	1.1
29	6774	200	116	55	176	43	840	910	76	14	3	0.13	1.2	1.3	1.2
30	5096	70	10	8	10	25	1300	600	136	8	7	0.3	1.7	1.1	2.0

Thus, the initial melt of the formation in deep and intermediate sites has been subjected to crystallization differentiation. Quantitative contents and ratios of rare-earth elements are the most sensitive for identification of the share of melt and composition of upper mantle substrate (Kogarko, 1998; Ryabchikov, 1988, Imamverdiyev, 2003). Rocks of the formations are somewhat enriched by light rare-earth elements, and also samarium (9.3-9.5 g/T) and ytterbium (3.1-3.2 g/T). The determined characteristics of behaviour of rare-earth elements are confirmed by spider diagram (Fig. 4), charted according to concentrations of rare-earth elements, normed to chondrite (Sun and McDonough, 1989).



а) б)

Fig. 3. The distribution of rare earth elements in the Eocene alkaline and subalkaline basaltoids of Talysh is normalized to chondrite (Sun and McDonough, 1989). Some of the analyses are taken from Vincent et al. (2005).

a) – Absarokite – shoshoniet – alkaline basalt complex: b) – Trachyandesibasalt – phonolite complex: Symbols see fig. 2.

By Ba/Sr and Rb/Sr ratios, tephrites, trachybasalts and melanocratic analcimites are positioned between mantle phlogopite and amphibole. However, notable enrichment of the rocks of the analyzed formation with barium (1,620-1,850 g/T) indicates that the initial melt has been enriched with this element. There are comparatively decreased concentrations of strontium (560-695 g/T) and rubidium (30-50 g/T). During the process of partial melting, metasomatically transformed mantle was obviously prevailing over the mantle phlogopite. Therefore, points of Ba/Sr and Rb/Sr ratios are somewhat shifted toward phlogopite (Fig. 5) (Mamedov, et. al., 2006).

The Talysh zone contains developed volcanic-plutonic associations of alkaline and subalkaline series of subalkaline olivine-basalt magma. Rocks of the trachybasalt-trachyandesibasalt-phonolite formation of the Talysh are characterized by mineral parageneses, corresponding to particular stages of crystallization.

From genetic perspective, study of indicatory values of mineral parageneses – along with restoration of stages of crystallization of various compounds of melts and hydrothermal solutions – allows one to trace processes of their evolution (Imamverdiyev, et. al., 2018, 2021).

Mineral parageneses of the trachybasalt-trachyandesite-basalt-phonolite formation of Talysh were partially studied by M.N. Mamedov, but more thoroughly studied by the author (Karimov, 2007) and indicator features were established during the evolution of primary magma.

By impregnations, rocks of the first complex are distinguished as follows ; clinopyroxene – plagioclase – biotite, olivine-clinopyroxene-chrome-spinel, olivine-clinopyroxene-plagioclase-leucite-titanomagnetite, clinopyroxene-plagioclase-hornblende, clinopyroxene-potassiumfeldspat-plagioclastic, and plagioclase – potassium-feldspat – analcime mineral parageneses. The rocks of the second complex in impregnations are determined as follows: plagioclase – clinopyroxene – magnetite, leucite – potassium-feldspat – clinopyroxene and olivine-clinopyroxene – plagioclase – titano-magnetite mineral parageneses (Mamedov, et. al., 2017; Karimov, 2020).

Results.

To summarize the data above, we may come to the conclusion that geodynamic non-homogenity of the basement, i.e. block structure of the Talysh zone, is reflected in the pattern of the evolution of the analyzed melt (Aliyev et.al., 2009). Therefore, in the conditions of low permeability of deep faults within the Astara elevation, the ascent of the primary melt to the upper structural stories of the Earth's crust was hindered. Thus, on one hand, accumulating inclusions of rocks and minerals melted completely , and on the other hand – the melt interacted with the containing rocks. In those conditions, subalkaline olivine-basalt melt in intermediate site was enriched by aquatic fluid, resulting in crystallization in impregnations and mostly of such water-bearing minerals as hornblende, biotite, analcite and others. There, under the control of water fluid, the initial melt underwent evolution in the composition from subalkaline olivine – biotite trachybasalt to sanidine trachyandesibasalt.

In the conditions of Qosmolyan –*Pilyachay* depression, which over the process of formation was controlled by transverse graben-like fault structures, the subalkaline olivine-basalt melt in intermediate sites interacted with the containing rocks comparatively less. Between the petrographic types of the formation, contrast – biomodality is hardly seen on the diagram, charted using the ratios of Ba/Sr and Rb/Sr. All points are located between the mantle phlogopite and amphibole. All this indicates that garnet-lherzolite substrate, under the influence of asthenospheric fluids, was subjected to metasomatic transformation.

Geologic-tectonical and magmatic analyses demonstrate that the analyzed zone is potentially ore-bearing. There, only several ore and non-ore manifestations and deposits can be seen. Ore deposits and manifestations are Kurlinskoe iron-arsenic, Duzabelskoe baryte-polymetallic, Mezhdarskoe copper, Gamarat copper-nickel, and also titanomagnetite sands, etc. Non-ore fossil deposits are Şindan qalasi and Astara zeolite deposits, Kashkahalskoe, Təzəkənd manifestations of Iceland spar and others. Ore deposits and manifestations are concentrated in the crossing points of transversal and longitudinal faults.

Zeolite-containing rocks are developed in Middle Eocene tuffogenic-sedimentary layers. Those rocks are observed to contain sedimentary-diagenetic analcime, natrolite, epigenetic laumontite, and also pink heulandites, forming tabular crystals with strong nacreous gloss. The zone was also found to have a number of manifestations of Iceland spar.

Conclusions.

1. During the Eocene, in the Talysh fold zone, as a result of the activation of transverse tectonic movements, faults were formed that complicated the Astara, Burovar and other longitudinal folded structures.

2. It has been established that the trachybasalt-basalt-trachyandesite-phonolitic formation of the region

under consideration consists of absarokite-shoshonite-alkaline basalt (Early-Middle Eocene) and trachyandesite-basalt-phonolitic (Late Eocene) complexes.

3. From the early phases of the manifestation of Eocene volcanism to the late phases, the change in the material composition along the lateral is expressed in the manifestation of more alkaline facies with a significant predominance of K over Na and with a greater correspondence to the differentials of the shoshonite series

4. Depending on the geological and geodynamic conditions, the initial melt of the formation was subjected to various stages of the crystallization process, which caused the formation of various mineral paragenesis.

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