

ГЕОЛОГІЯ РОДОВИЩ КОРИСНИХ КОПАЛИН



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УДК 549.553

DOI: <http://doi.org/10.17721/1728-2713.112.04>

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ZEOLITE FIELDS OF AZERBAIJAN

(Представлено членом редакційної колегії д-ром геол. наук, доц. Сергієм ШНЮКОВИМ)

Background. Zeolites are the best adsorbents and therefore attract close attention of researchers, and at the same time find wide application in various branches of industry and agriculture, and over time the areas of their application are constantly expanding. Natural zeolites - clinoptilolite and mordenite are of particular importance.

Methods. To study the composition of zeolites from various fields, more than 50 chemical analyzes of zeolitized tuffs were carried out, the smallest fractions of clinoptilolite tuffs were subjected to mineralogical analysis. The refractive indices of the microscale aggregate of clinoptilolite were determined and the amount of minerals was calculated, the diffraction data of zeolites were obtained at room temperature on a diffractometer DRON-3.

Results. chemical composition. According to the results of chemical analyses, it was found that the composition of zeolite group minerals and zeolitized tuffs of the Gazakh trough is characterized by a high silica content, the predominance of ferric oxide over protoxydic, calcium over magnesium and sodium over potassium. It was found that the magmatic zeolite itself is represented by analcime, which in the form of xenomorphic segregations is located in the interstitium of earlier released rock-forming minerals, such as olivine, clinopyroxene, plagioclase, biotite, hornblende and others in the composition of teschenites of the Tugh and Kalakhan intrusions. The next genetic type of zeolites is also analcime, which was formed as a result of metasomatic transformation of high-temperature leucite.

Conclusions. It was established that in most cases the initial material for the formation of zeolites are ash tuffs of trachyandesite-basalts, andesites, dacites and rhyodacites. The tectonomagmatic regime is one of the decisive factors in the formation of analcime and clinoptilolite-mordenite deposits.

Keywords: natural zeolites, formation conditions, zeolitized tuffs, Aydagh deposit.

Background

Statement of the problem. Zeolites in Azerbaijan as a raw material of industrial interest began to be studied about a quarter of a century ago, when their large deposits were discovered. The research was conducted, on the one hand, from the point of view of a detailed definition of all possible properties, and on the other hand, geological exploration work was carried out to delineate their deposits and determine reserves. Natural zeolites on the territory of Azerbaijan have been studied sufficiently and covered in various publications in national and foreign editions. Based on the collected materials and personal research, information about natural zeolites of Azerbaijan is summarized in the monograph (Mamedov et al., 2000). This paper examines the geological conditions of formation of zeolite-bearing complexes, their classification, mineralogy, physicochemical conditions of formation and some areas of use of natural zeolites of Azerbaijan in various sectors of agriculture and industry (Kashkai, & Babaev, 1976; Mamedov et al., 2000; Tagiev, 1999). Among natural zeolites, magmatic, hydrothermal and sedimentary-diagenetic types of zeolite formation are dedicated (Mamedov, Kerimov, & Abdullaeva, 2005). Zeolites of Azerbaijan in the mineralogical aspect are divided into one-dimensional, two-dimensional and three-dimensional types. The listed genetic and various structural-mineralogical types of zeolites are associated mainly with the Late Cretaceous and Cenozoic geological complexes of the Azerbaijan part of the Caucasian segment of the Alpine belt.

The purpose of this work is to study the industrial value, catalytic properties of zeolites and their ability to cation exchange, absorption and loss of water, and, in addition, the

possibility of industrial use of this valuable mineral raw material, together with the advantageous location of the ore region of the Gazakh trough with large deposits of zeolite-containing tuffs (Aydagh, Agdagh, Yukhari Oksyuzli, Tatly, etc.).

The tasks to be solved in this work are the results of chemical analyses of zeolitized tuffs, as well as geological, geochemical, and petrological studies conducted in the study area.

Geological features of zeolite fields of the Azerbaijan. Zeolite-bearing formations are mainly widespread among the Late Cretaceous and Cenozoic complexes in the Gazakh, Agjekend, Agdere, Khojavend, Gochas troughs, in the Vandam and Talysh zones, as well as in the Kura intermountain depression, Mountain Talysh, Nakhichevan, Kalbajar. Among natural zeolites, the most valuable are their high-siliceous forms, which are represented by the Aydagh, Kemerli, Gaimagli, Yukhari Oksyuzli and Tatly fields (Gadjiev et al., 2023; Karimov, 2022; Mamedov, 1999). In the Talysh-Tarom structural-formational zone, analcime develops along the ash cementing mass and makes up 40–70 wt% of the rock volume (Azizbekov, & Mamedov, 1974).

In addition to the above-mentioned fields, clinoptilolite manifestations were found among the Late Cretaceous tuffaceous-sedimentary strata of the Agdere trough (Sugovushan village). Here, ash clinoptilolite tuffs alternate with whitish-gray tuffs. Clinoptilolite is associated with heulandite, montmorillonite, analcime, and calcite. The clinoptilolite content varies from 40 to 60 wt%.

The Shurtan manifestation, located at a distance of about 2.5 km from the villages of Kharkhaput and Gulistan in the Goranboy region, is characterized by the highest analcime

content (about 90 wt%). Here analcimized tuffs (Eocene) lie conformably among flaglike limestones of the Campanian and Maastrichtian stages. Analcimized fine-grained tuffs were found among the Late Cretaceous clinoptilolite tuffs of the Agdere trough. Authigenic or sedimentary analcime was found in the middle part of the tuffaceous-sedimentary stratum of the Late Eocene, developed in the Burovar (Vilashchay, Ulumchay, etc.) and Astara (Tangaryuchay, Astarachay, etc.) uplifts. Individual well-faceted crystals of analcime were noted in the breccia of the Gobu mud volcano (near Baku), consisting of fine- and medium-grained Campanian sandstone (Amirov, Mamedov, & Mamedov, 1977).

Clinoptilolite manifestations are established in Talysh Mountains, Araschay zone, in Agdere and Kalbajar troughs. In Talysh Mountains (Abdullaev, Alizade, & Kheirov, 1979) clinoptilolite in the composition of tuffaceous-sedimentary strata of the Middle Eocene is associated with heulandite, calcite and analcime. In Araschay zone it is also established in the composition of ash tuffs of the Middle Eocene. Tuffs are characterized by greenish-gray, blue color. These tuffs in the area of the villages of Kyuki, Yukhary Remeshin, Garaboy in the form of a layer of small thickness alternate with white silicified ash tuffs. The length of the zeolite-bearing strata reaches 15 km, the thickness varies from 6 (in the southeast) to 10 m (in the northeastern edge of the Garaboy village). Clinoptilolite is present in tuffs in the form of small crystals of 0,1–0,01 mm. It is associated with quartz, feldspar, etc.

Mordenite-clinoptilolite tuffs are found in the Kelbajar superimposed trough. This field is located near the village of Allolar. The area of clinoptilolite-mordenite mineralization is about 10 km². Here, the crystallization process is associated with changes in Eocene andesites and their tuffs.

In the Aghjakend trough, in contrast to the Gazakh trough, dacite-rhyolite volcanism of the Coniacian and basalt-andesite-basalt of the Santonian period is developed. Upper Jurassic, Cretaceous and Paleogene volcanogenic, volcanogenic-sedimentary and sedimentary formations take part along the structure of this trough. Here, zeolite mineralization has a hydrothermal genetic type and mainly fills cracks, geodes, voids, etc. Zeolitization is rare for rock-forming minerals, especially plagioclase. In the Azerbaijan part of the Lok-Garabagh structural-formational zone, the most promising clinoptilolite and clinoptilolite-mordenite fields is the Gazakh trough, which is located in the subsidence zone of the Lesser Caucasus meganticlinorium under the Quaternary molasses of the Middle Kura Depression. The trough is filled mainly with Upper Jurassic effusive, sedimentary-pyroclastic and normal-sedimentary complexes. All zeolitized bands conformably lie in the same stratigraphic horizon, i.e. they are located among the late Santonian and early Campanian deposits (Abdullaev, Alizade, & Kheirov, 1979).

In general, three promising areas can be identified for the Gazakh trough: northwestern, central and eastern. In the northwestern area, clinoptilolite layers, 20–25 km long, can be traced from the village of Alibayramly and continue into the territory of the neighboring republic. Here, mordenite significantly predominates over clinoptilolite. At the same time, the silica content in composition of the tuffs is noticeably high. In the eastern area of the Gazakh trough, which includes the Aydagh field, clinoptilolite predominates over mordenite. Here, the trasses, which have a relatively coarse-grained granulometry, are less zeolitized and are a product of the early stage of the explosion of late Santonian volcanism (Kuliev, & Gamzaev, 1976; Rasulova, 2015; Rasulova et al., 2017). In the marginal parts of the Gazakh trough, the Aydagh, Tatty, Korogly, Agdagh, Karamly and Gaimagly clinoptilolite and clinoptilolite-mordenite fields are developed. Among the listed fields, the largest and most well-studied is the Aidagh field,

which is the main object of research. The field is located in the monocline of the Korogly synclinal structure of the second order and is confined to the intersection zone of the anti-Caucasian fault with the all-Caucasian fault. At the intersection nodes of the structures of both directions, a network of tectonic fractures arose, which caused the development of hydrothermal metasomatism and, in particular, zeolitization of ash hyaloclastites (Karimov, Pashayev, & Pashayeva, 2024; Mykhailov, Kryvdic, & Sharygin, 2016; Rasulova et al., 2017). Ash tuffs are massive and fine-grained and occur among carbonate deposits of the upper Santonian-Campanian stage in the form of a bedded deposit with an average thickness of 25–30 m. The width of the outcrop of tuffs on the surface is 20–120 m with a total length of up to 3 km. Faults divide the field into 3 sections: western, central and eastern. The most promising is the central section, where the length of the outcrop on the surface is 200 m. The presence of three layers has been established: 1) light-grey tuffs; 2) brownish-grey tuffs; 3) lower bluish-grey trasses (Fig. 1,2).

Methods

This article is based on the analysis of the materials of the author's field and laboratory research, studying the late Cretaceous volcanism of the Gazakh trough and the associated fields of high-silica zeolites. To solve the tasks, about 50 chemical analyzes of zeolitized tuffs were carried out, and the results of geological, geochemical, and petrological studies in this area were used with the involvement of fund and published materials; schematic geological maps of the Aydagh field were compiled based on personal field observations. According to the data of granulometric analyses performed by Chelishchev, Berenshtein, and Volodin (1987), the smallest fractions of clinoptilolite tuffs were subjected to mineralogical analysis. The refractive indices of the microscale aggregate of clinoptilolite (N=1.480) were determined and the amount of minerals was calculated: clinoptilolite – 76–80 wt%, quartz – 14–16 wt%, calcite – 2–2.5 wt%.

Based on the results of chemical analyses, it was established that the composition of the zeolite group minerals and zeolitized tuffs of the Gazakh trough are characterized by a high silica content, the predominance of ferric oxide over protoxydic, calcium over magnesium and sodium over potassium.

Diffraction data for zeolites were obtained at room temperature on a diffractometer DRON-3 (CuCa -radiation, Ni-filter, 30 kV, 20–26 mA, counter speed 0.50 θ/min.). Each sample was studied 3 times. The position of the KBrO3 line (2θ=20.2120) and quartz (2θ=40.2980; 50.1460) were used as an internal standard. The accuracy of the determination was ±1 wt%.

Results

Late magmatic zeolite is represented by rock-forming analcime. It is located in the form of xenomorphic segregations in the interstices of previously separated plagioclases, clinopyroxenes, biotites, and hornblende in the Tugh and Kalakhan teschenites. According to X-ray diffraction (a=13.72 Å) and chemical analyses (Table 1, an. 1, 2), its composition is close to theoretical. Hydrothermal analcimes contain a significant concentration of rubidium (100–200 ppm), barium (200–259 wt%), and potassium oxide (1.5–2.5 wt%). In all likelihood, this analcime is a product of primary leucite transformation. The content of the mentioned mineral in the above-mentioned rocks often reaches 40–60 wt%. Considering the high content of alumina (Al₂O₃ – 23.69 wt%) and sodium (Na₂O – 12.78 wt%) in the composition of these analcimes and the sufficient area of their distribution, this type may be of industrial interest (Rasulova et al., 2017).

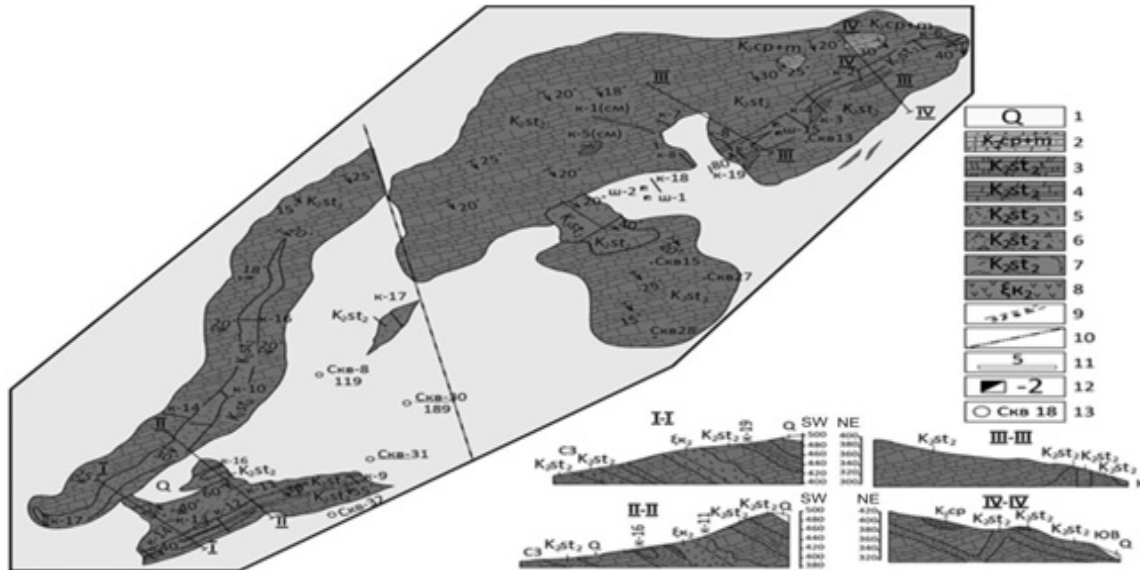


Fig. 1. Schematic geological map of the Aydagh field:

1 – Quaternary sediments: loam, sandy loam; 2 – Campanian-Maastrichtian stage: limestones of whitish-grayish colour, coarse-grained, sandy; (3–7) Upper Santonian substage: 3 – red-coloured weakly sandy limestones; 4 – marl-like limestones, pelitomorphic, highly fractured; 5 – zeolite-bearing tuffs, bluish-gray; 6 – zeolite-bearing tuffs, highly silicified and brecciated; 7 – zeolite-bearing blue "trasses"; 8 – Upper Cretaceous: diorite porphyrites; 9 – hydrothermally altered rocks; 10 – faults; 11 – ditches and their numbers; 12 – pits and their numbers; 13 – wells and their numbers (Scale 1:2000)

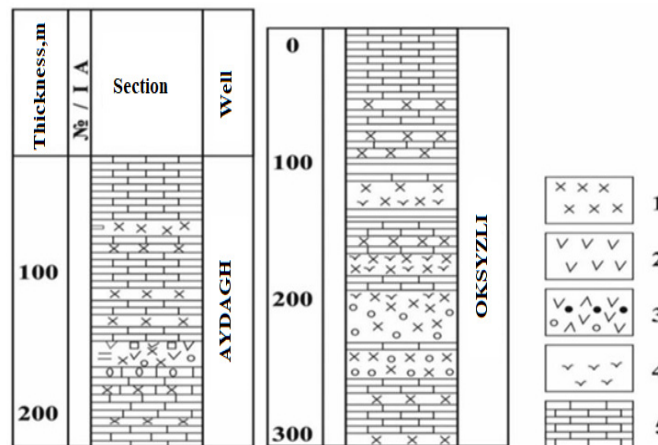


Fig. 2. Lithological section of the Aydagh and Oksyzli fields:

1 – ashes, ash tuffs (clinoptilolite); 2 – marl-like ashes (siliceous-analcime); 3 – breccia lithoclastic and crystalline-vitroclastic tuffs; 4 – lenses and bentonite inclusions; 5 – organogenic pelitomorphic limestones

Macroscopically the clinoptilolite tuff is characterized by light, light-gray and greenish-gray color. Clinoptilolite tuffs have a fine-grained and dense structure. Under the microscope, a cryptogranular, acicular, scaly structure of clinoptilolite tuff is observed. In addition to the latter, as a cementing mass, shapeless calcite and dolomite precipitates are noted. Besides them, devitrified remains of brownish-gray glass of dacite and rhyodacitic composition often participate in the different level compositions. In addition, angular fragments of quartz (0,02–0,4 mm), feldspar (0,04 mm) and biotite (0,015–0,1 mm) tablets were found in thin sections. Small chlorite flakes sometimes form isolated clusters. Minor amounts of iron hydroxide and clusters of cryptocrystalline carbonates forming thin intergrowths with zeolites are found. According to the granulometric composition, clinoptilolite tuffs are represented by the following fractions: > 0.25 mm – 4,7–18,6 wt%; 0.25–0,1 mm – 5–12,1 wt%; <0,1–0,01 mm – 46,8–64,2 wt%; <0,01 mm – 21,2–31,9 wt% (Table 1, analyzes 1, 2). The

results of the analyzes show that the amount of zeolites in the light fraction of 0,1–0,01 mm varies from 75 to 95 wt%, the rest of the fraction is represented by aluminosilicates, partially altered feldspars and carbonates. Biotite and chlorite are heavy fractions and predominated. Hornblende, celestine, zircon, ilmenite, magnetite and single grains of tourmaline, sphene, augite, garnet and pyrite were found as accessory minerals. According to Mamedov, Kerimov, and Abdullaeva (2005) clinoptilolite in the Aydagh field is associated with mordenite, heulandite, natrolite, stilbite, analcime and other minerals in the form of needle-like and fibrous clusters. Most often it is colorless. Clusters of small (0,01–0,03 mm) clinoptilolite crystals form pseudomorphs mainly on feldspars. In the cementing mass, clinoptilolite develops on feldspar and quartz. In most cases, relics of volcanic glass are observed. The refractive indices determined for clinoptilolite from the Aydagh deposit are Ng=1.480–1.483; Np=1.478–1.481. Associated

heulandite is characterized by higher refractive indices: $N_g=1.501$; $N_p=1.497$.

A study of the chemical composition of clinoptilolite and clinoptilolite-mordenite tuffs (Table 1, analysis 3–8) showed a high silica content, a predominance of ferric oxide over protoxydic, calcium over magnesium and sodium over potassium. In general, the chemical composition of hyaloclastite tuffs, which make up individual sections of the Upper Santonian and Lower Campanian, changes from northwest to east toward an increase in alkalinity, iron content, and a decrease in calcareous content. As a result of studying the chemical composition (see Table 1,

analysis 3), it was established that the Aydagh clinoptilolite belongs to the sodium-calcium variety with a reduced potassium content. However, these changes do not affect the general characteristics of the tuffs and suggest that they belong to a single primary magma of dacitic and rhyodacitic composition (Pilchin, & Eppelbaum, 2020).

According to the results of spectral analysis, the following were established in the composition of zeolitized tuffs and "trasses" of the Gazakh trough (ppm): strontium 210, barium 200, titanium 400, cerium 80, zinc 200, lead 200. The listed elements can either be isomorphically part of the crystalloclasts or be dispersed in the cementing mass (Table 1).

Table 1

Chemical composition of clinoptilolite tuffs of the Gazakh trough, (Mamedov, Kerimov, & Abdullaeva, 2005)

Composition	Analcime, wt%		Clinoptilolite tuffs, wt%							
	1	2	3	4	5	6	7	8	9	10
SiO ₂	54.23	52.47	65.95	64.66	67.50	68.25	69.74	67.8	63.0	67.7
Al ₂ O ₃	24.16	24.62	12.13	11.17	10.63	10.50	11.13	11.1	9.97	10.5
Fe ₂ O ₃	—	0.41	1.22	1.26	0.30	0.11	0.24	0.24	0.40	0.36
FeO	0.06	—	0.07	0.05	0.07	0.05	—	—	—	—
MnO	—	—	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
MgO	—	0.32	0.99	1.09	0.32	0.75	0.87	0.54	1.12	0.65
CaO	0.63	1.40	3.63	3.70	8.15	6.68	5.68	6.91	9.82	7.29
Na ₂ O	12.74	11.16	1.37	2.23	2.12	2.10	2.12	1.69	1.42	1.51
K ₂ O	0.34	1.47	1.95	2.15	1.70	2.10	2.12	1.69	1.68	2.10
H ₂ O + 110	7.94	8.05	8.26	8.74	7.06	8.56	8.08	9.24	12.1	9.05
H ₂ O -110	0.20	—	3.38	4.26	2.92	1.04	1.98	—	—	—
Σ	100.30	99.90	98.97	99.37	100.72	100.01	99.98	99.3	99.6	99.2

Clinoptilolite is transparent crystals 0.03–0.5 mm in size, pseudorhombic in habit, with perfect cleavage on (010) and bright adamantine luster. In powder diffractograms, clinoptilolite is characterized by diffraction effects with interplanar distances of (9.0–9.1 Å, 3.96–3.97 Å, 2.97–2.98 Å and a number of weaker ones). In the diffractograms, intense reflections $d=8.9–8.98$; 3.95; 3.4 and 2.96–2.97 Å, as well as a number of other weak reflections $d=7.8–7.91$; 6.66–6.68; 5.2–5.28; 5.09–5.1; 3.16–3.21 and 2.78–2.79 Å allow us to identify the groundmass as clinoptilolite (Fig. 3).

Unlike clinoptilolite, natural mordenite is clearly defined by X-ray diffraction analysis. Under a microscope, the structure of mordenite is represented by fibrous-diverse or radial-fibrous aggregates of the finest needle-shaped crystals with low double refraction. Extinction is direct, elongation is negative. Mordenite is formed over volcanic glass, replacing both glass fragments and glass of the cementing groundmass. Intense reflections $d=9.04–9.16$; 6.59–6.63; 4.49; 3.98; 3.47; 3.35; 3.20–3.22 Å on diffractograms allow us to identify mordenite (Fig. 4).

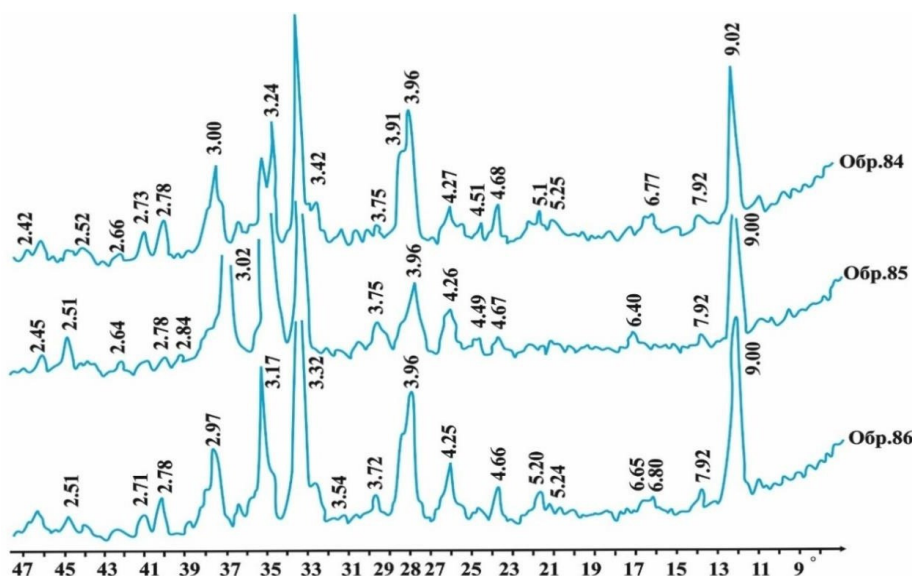


Fig. 3. Diffractograms of zeolitised "trasses" of the Aydagh field

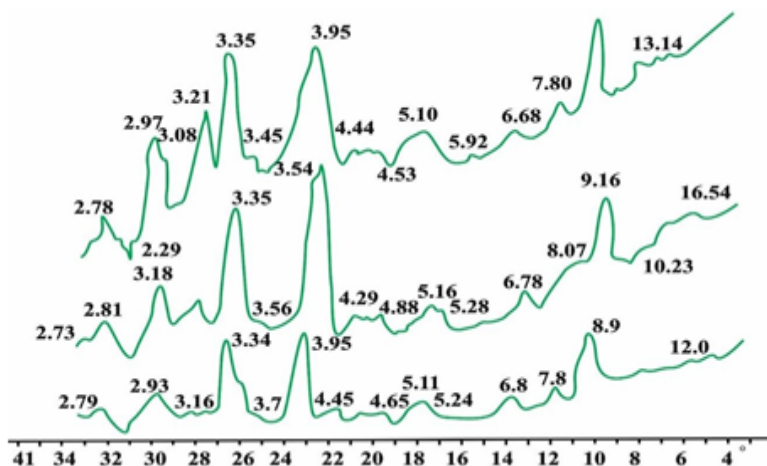


Fig. 4. Diffractograms of mordenite with clinoptilolite in vitroclastic tuffs

Discussion and conclusions

Unlike clinoptilolite rocks, which often contain cristobalite alongside with quartz, mordenite rocks contain only quartz. Mordenite rocks are undistinguishable from clinoptilolite rocks under a microscope. Hydrothermal zeolites, unlike magmatic analcime, are characterized by a wide variety of mineral composition and wide distribution. They are confined to amygdules, voids, cracks and other formations of volcanic rocks. These zeolites are represented by analcime, natrolite, mesolite, scolecite, laumontite-leonhardite, stilbite, ethistilbite, chabazite, heulandite, clinoptilolite, mordenite, thomsonite, and wairakite. Hydrothermal analcime, which is of interest, forms unclearly bounded crystals of milky-white and grayish color. Relatively large well-bounded crystals of tetragonal-trioctahedral habit, 2.5 cm in size, were found in the composition of leucite phonolite and megaplagioporphyritic latite of the Talysh-Tarom zone (Peshtasar, Razi villages) (Azizbekov et al., 1979; Kerimov, 2007). Concentrically located chloritized microinclusions, needles of the aegirine, etc. were found in these crystals. At the same time, relatively small but well-bounded segregations of them were found in the composition of absarkites of the Gosmalyan trough of this zone. A noticeable concentration of rubidium (100–200 ppm), barium (200–250 ppm) and potassium oxide (1.5–2.5 wt%) was found in analcimes. This analcime is obviously a product of the transformation of primary leucite. The content of the mentioned mineral in the noted rocks often reaches 40–60 wt%.

Sedimentary-diagenetic analcime is developed in the Talysh-Tarom structural-formational zone. Here, analcimized trachyandesite basalt tuffs are confined to the southwestern edge of the Astara uplift and are traced from the Gosmalyan trough in the southeastern direction and through the Shandan tower pass to the territory of Iran (Early Eocene). Fine-grained analcimized tuffs with a thickness of 5 to 20 m overlap the eroded surface of the Danian-Paleocene tuffaceous-sedimentary complex. The upper horizon is represented by medium-coarse-grained analcime-sanidine trachyandesite basalt tuffs (trachytes). Here, as the size of rock fragments and minerals increases from bottom to top, the analcimization process decreases. Alongside with analcime, heulandite and laumontite are noted in subordinate quantities in tuffs.

Laumontite-leongardite manifestations were established in the composition of the cementing material of the basal conglomerate, confined to the base of the flyshoid strata of the Middle Eocene of Talysh. Heulandite zeolitization in the

form of thin (0.2–10 cm) interlayers is located in the lower part of the Middle Eocene tuffaceous-sedimentary strata. The heulandite interlayer has a meat-gray color and medium-fine-grained granulometry. Heulandite develops along the ash cementing mass of the noted tuffaceous sandstones.

Analysis of the distribution of the listed fields of sedimentary-diagenetic zeolite formation showed that in most cases the initial material for the formation of zeolites are ash tuffs of trachyandesite-basalts, andesites, dacites and rhyodacites. The diversity in the composition of the products of explosive activity of the Late Cretaceous and Cenozoic volcanism is associated not only with the conditions of the tectonomagmatic regime, although it is one of the decisive factors in the formation of analcime and clinoptilolite-mordenite fields and these volcanoes is one of the main factors in assessment of zones of tectonomagmatic regime of Earth's interior (Bayraktutan, & Ganbarova, 2024; Nasibova, Mukhtarova, & Ganbarova, 2024). Undoubtedly, the initial material for the formation of analcime and clinoptilolite-mordenite tuffs were trachyandesite-basalt, andesite-dacitic, dacitic and rhyodacitic ash particles of hyaloclastites of the Late Cretaceous (Upper Santonian, Lower Campanian) and Cenozoic (Paleocene, Eocene). Eruptions of the noted hyaloclastites occurred in submarine and subareal conditions (Ismail-zade, & Mustafaev, 1964; Kerimov, 2016; 2020; Mamedov, Babaeva, & Kerimov, 2017; Nasibova, Mukhtarova, & Ganbarova, 2024).

As is known, in the Late Cretaceous (Upper Santonian) within the Caucasian segment of the Mediterranean belt, due to ongoing subduction processes, there is a decrease in the permeability of longitudinal magma-conducting faults, and the activity of transverse faults increases (Chkheidze, 1981; Mikhailov, 1975; Van der Boon et al., 2015). In this regard, the rise of medium, medium-acid, acidic viscous melt to the earth's surface is hampered and the volcanic vent is blocked. As the lower parts of the magma-conducting channel become enriched in volatile components, high-pressure conditions are created. A change in the pressure ratio contributes to the fragmentation and ejection of medium and medium-acid hyaloclastites. At the same time, the upper part of the material of the sealed volcanic centers is subjected to fragmentation to a lesser extent, therefore the early ejecta product corresponds to coarse-grained, subsequently zeolitized tuffs. The products of the middle and lower parts of the blocked channels experience greater

fragmentation. The latter are ejected in the form of small ash hyaloclastites and are deposited in the shelf zone of the nearby sea. Here, due to the interaction of hot ash hyaloclastites with cold sea water in alkaline conditions, devitrification of these glasses occurs with the formation of analcime, clinoptilolite-mordenite-heulandite zeolitization.

1. The formation of zeolite fields are determined mainly by the composition of the source material, the facies conditions of its deposition and the nature of the catagenetic transformations of the host rocks. The source material for the formation of zeolites is, as a rule, volcanic glass of acidic, medium, rarely basic composition, contained in tuffs.

2. The local (or areal) distribution of analcime, heulandite, clinoptilolite and mordenite tuffs around volcanic centers indicates that the explosive activity of volcanoes is characterized by a central type of eruption, i.e. they are located in the zone of intersection of longitudinal and transverse faults.

3. Analcime, heulandite, clinoptilolite and mordenite tuffs, which form manifestations and large fields, are the product of the transformation of ash trachyandesite-basalt, andesite-dacitic, dacitic and rhyodacitic hyaloclastites in an alkaline marine environment.

4. The frequent occurrence of mordenite and clinoptilolite in the same rocks proves that the conditions of their formation overlap, but nevertheless, mordenite rocks, unlike clinoptilolite, often gravitate towards the contacts of subvolcanic rhyolite bodies and faults, and are found among dense limestones and near lava flows and coarse tuffs.

5. It is recommended to calculate the resources of the Aydagh and other zeolite fields and their use in medicine for the treatment of various diseases, as well as for the purification of contaminated drinking water, drying and purification of substances (radionuclides), additives in the production of cement, components of fertilizer mixtures, etc.

Sources of funding. This study did not receive any grant from a funding institution in the public, commercial, or non-commercial sectors.

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Отримано редакцію журналу / Received: 14.12.25

Прорецензовано / Revised: 16.01.26

Схвалено до друку / Accepted: 18.02.26

Опубліковано / Published: 27.02.26

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ЦЕОЛІТОВІ РОДОВИЩА АЗЕРБАЙДЖАНУ

Вступ. Цеоліти є найкращими адсорбентами, тому привертають пильну увагу дослідників і знаходять широке застосування в різних галузях промисловості та сільського господарства, а сфери їх використання постійно розширюються. Особливе значення мають природні цеоліти – кліноптилоліт і морденіт.

Методи. Для вивчення складу цеолітів із різних родовищ було проведено понад 50 хімічних аналізів цеолітизованих туфів; найдрібніші фракції кліноптилолітових туфів піддано мінералогічному аналізу. Визначено показники заломлення мікролускуватого агрегату кліноптилоліту та розраховано кількість мінералів; дифракційні дані цеолітів отримано за кімнатної температури на дифрактометрі ДРОН-3.

Результати. Проаналізовано стан вивченості та деякі особливості природних цеолітів Азербайджану різного мінерального та хімічного складу. За результатами хімічних аналізів встановлено, що склад мінералів групи цеолітів та цеолітизованих туфів Газахського прогину характеризується високим вмістом кремнезему, переважанням оксиду заліза (III) над оксидом заліза (II), кальцію над магнієм та натрію над калієм. З'ясовано, що власне магматичний цеоліт представлений анальцимом, який у вигляді ксеноморфних виділень локалізується в інтерстиціях раніше виділених породотвірних мінералів, таких як олівін, клінопіроксен, плагіоклаз, біотит, рогова обманка та інші у складі тешенітів Тугської та Калаханської інтрузій. Наступним генетичним типом цеолітів також є анальцим, що утворився внаслідок метасоматичного перетворення високотемпературного лейциту.

Висновки. Встановлено, що здебільшого вихідним матеріалом для формування цеолітів є попільні туфи трахіандезитобазальтів, андезитів, дацитів та риодацитів. Різноманітність за складом продуктів експлозивної діяльності пізньокрейдового та кайнозойського вулканізму пов'язана не тільки з умовами тектономагматичного режиму, хоча він і є одним із вирішальних факторів формування анальцимових та кліноптилоліт-морденітових родовищ.

Ключові слова: природні цеоліти, умови формування, цеолітизовані туфи, Айдазьке родовище.

Автор заявляє про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

The author declares no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; in the decision to publish the results.