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The reservoirs and potentials of perlite in Iran (A case study on perlite reservoirs of middle cenozoic volcanic zone of Mianeh in East Azerbaijan province)

Adel Afkhami Nahand*

Department of Geology, Urmia University, Urmia, Iran

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Key words: Perlite, Expanded, Lightweight materials, Filtration.

Abstract

Perlite is a type of volcanic stone with acidic composition which forms in water environment. It has a glass-like texture in which spherical shapes are formed (i.e. water content of 3 to 5 percent). Heating the perlite (700 to 1200 °C) contributes to its loss of molecular water content and increase of volume up to 10 times the extent of which is dependent upon containing molecular content. Perlite is widely used in diverse industries due to its low density, low conductivity, neutrality, non-combustion, low hardness, good brightness, absorption, and proper strength. In most of the applications, perlite is used in expanded form but in some situations, the raw perlite is also used based on its physicochemical properties in casting industry, abrasives, and as sources of silica. Of the most significant applications of processed perlite, one could point to construction materials and prefabricated parts, soil fertilizer and livestock feed in agriculture, fillers in some industrial applications, and thermal insulations in chemical industries for production and refining food and medicinal materials. Turkey, Greece and United States have respectively the highest levels of perlite reservoirs in the world. A major proportion of perlite reservoirs in Iran are found in Cenozoic volcanic areas. Most of the discovered perlite reservoirs in Iran are located at the north of Mianeh Zone. This zone is located near Sahand and Ghar E-Chaman-TorkamanchayZone which leads to eastern sections of Bazghosh in northwest-southeast direction. The ShirinBalagh, Dash Atan, Sari Ghomish, Ajmi, Abic, Ashlagh Chai, etc. are located in this zone.

***Corresponding Author:** Adel Afkhami Nahand ✉ afkhami_adel@yahoo.com

Introduction

Perlite is widely used in widely used in diverse industries due to its low density, low conductivity, neutrality, non-combustion, low hardness, good brightness, absorption, and proper strength. In most of the applications, perlite is used in expanded form but in some situations, the raw perlite is also used based on its physicochemical properties in casting industry, abrasives, and as sources of silica. Of the most significant applications of processed perlite, one could point to construction materials and prefabricated parts, panels, filler isolations, sound insulation bricks, etc., one of the factors affecting plant growth and seed development in horticulture, soil and grass improvement, soil fertilizer and livestock feed in agriculture, fillers, thermal insulations, fireproofs, explosives, absorbers, prefabricated products, and drilling mud used in filters in some industrial applications, and production and refining sugar, pharmaceuticals, beverages and water purification within chemical industries, and fertilizer, pesticides, herbicides and livestock feed in agricultural sector. The perlite reservoirs are mostly found in Cenozoic volcanic areas of Iran. This zone is located in Mianeh Region, around Shand Mountain and in northwest-southeast direction. Hitherto, most of the discovered resources of perlite discovered in Iran are in Mianeh Zone. The ShirinBalagh, Dash Atan, Sari Ghomish, Ajmi, Abic, Ashlagh Chai, etc. are located in this zone. Turkey, Greece and United States have respectively the highest levels of perlite reservoirs in the world. The U.S. Geological Survey (USGS) estimated that the basic level of global perlite reservoirs is 200 million tons. Some other areas in Ghaflan Mountain Chain, Dare-Si Garden, Toop Ghare, northeast of Amir Abad, Chehel-Noor Mountain, Khatb Area, and Sefid Khane are among the perlite containing ones. In addition, valuable reservoirs have been reported around Birjand, Ferdows, Tabas, Taibad, Gonabad, Nain, Kashan, and some regions of Sistan and Baluchestan Province. The most famous currently active mines of perlite in Iran are Dash Atan, Shirin Balagh and Sefid Khane. The corresponding formations data back to Tertiary period and quaternary sedimentary deposits. The stones in these areas are usually of volcanic types. The distribution of perlite in Iran is significant and it has been reportedly discovered in southeast regions over Paleogene volcanic rocks, Se-Changi Region, Azerbaijan Region especially Mianeh Town, east of Iran such as Gonabad and Ghaen, around Birjand, Ferdos and Tabas as well as Sistand and Baluchestan Province and Nain and Kashan. The accompaniment of discovered perlites in Iran with alunite, kaolinite and zeolite, especially in Azerbaijan Zone, manifests the dependence of perlites upon altered Tertiary volcanic rocks. The aim of this study was reservoirs and potentials of perlite in Iran (A Case Study on Perlite Reservoirs of middle Cenozoic volcanic zone of mianeh in East Azerbaijan province).

Materials and Methods

Genesis Characteristics of Perlite

Perlite includes 20% quartz with feldspar and mica. Sometimes, it includes ferromagnesian materials too. Perlite has a magmatic genesis and most of the high-quality perlites found data back to third and fourth geological periods. If perlite is altered, it changes into montmorillonite, opal and chalcedony. This material is widely found in young volcanic areas of present era.

Geology and distribution of perlite in Iran

The distribution of perlite in Iran is significant and it has been reportedly discovered in southeast regions over Paleogene volcanic rocks, Se-Changi Region, Azerbaijan Region especially Mianeh Town, east of Iran such as Gonabad and Ghaen, around Birjand, Ferdos and Tabas as well as Sistand and Baluchestan Province and Nain and Kashan. The accompaniment of discovered perlites in Iran with alunite, kaolinite and zeolite, especially in Azerbaijan Zone, manifests the dependence of perlites upon altered Tertiary volcanic rocks.

Result and discussions

Major Perlite Reservoirs in the World

Turkey, Greece and United States have respectively the highest levels of perlite reservoirs in the world. The U.S. Geological Survey (USGS) estimated that the basic level of global perlite reservoirs is 200 million tons.

Major reservoirs and potentials of perlite in Iran

Some other areas in Ghaflan Mountain Chain, Dare-Si Garden, Toop Ghare, northeast of Amir Abad, Chehel-Noor Mountain, Khatb Area, and Sefid Khane are among the perlite containing ones. In addition, valuable reservoirs have been reported around Birjand, Ferdows, Tabas, Taibad, Gonabad, Nain, Kashan, and some regions of Sistan and Baluchestan Province. The most famous currently active mines of perlite in Iran are Dash Atan, Shirin Balagh and Sefid Khane. The corresponding formations data back to Tertiary period and quaternary sedimentary deposits. The stones in these areas are usually of volcanic types.

Major Perlite Reservoirs in Middle Cenozoic Zone

Dash Atan (Shahriar) Perlite

The Shahria Perlite Mine is located 95km away from transit road of Tabriz-Tehran, in the area of Bostan Abad Town in Ticme Dash Parish the center of which is Ghar-E- Chaman, and on the lands of Khoshk Nab Village. The proved and probable reserve of the mine are 720 and 8100 thousand tons. The exploitable average grade of material with expanded quality in different blocks is 20 times. The perlites of Shahriar Mine are in bright to grayish green color and their level of biotite-type mafic minerals is significant low. In addition, in some regions, especially bottom of valleys, black-colored perlites with thin layers of ferriferous silica have been observed but their reserve is insignificant. The mineral material is this area is placed as a large vein with N20-NE 18 direction. The gradient of the line is 36-40 degrees toward northwest and its mean thickness is 15 cm (Fig. 1).

Fig. 1. Active Dash Atan Mine.

Ashlagh Chai perlite reserve

This reserves is located 6 km away from west of Mianeh and along the Mianeh-Tabriz Road. The area of its outcrops is about 240 thousand m^2 which regarding the topographic shape of the reserve, one can extract a minimal depth of 20m of perlite from the whole area of the outcrops. The extractable amount of perlite in Ashlagh Chai is estimated to be 14 million tons. The microscopic studies of perlite samples of this areas showed their porphyry-perlitic texture. About 30 to 30% of the rock volume is made of phenocrystal, 15 to 20% is made up of plagioclases, and the rest is composed of quartz, biotite and amphibole. In reference to previous studies, this type of rock could be called andesite or quartz andesite (Fig. 2).

Fig. 2. Active Ashlagh Chai Mine.

Ajmi perlite reserve

This reserve is located 25km away from west of Mianeh, along Mianeh-Tabriz Road and in southeast of Ajmi Village. Almost five kilometers of the way to the mine is covered by soil. The type of perlite found in this reserve is mostly made up of greyish perlite and due to the fact that a major portion of this reserve is covered by Pliocene and quaternary deposits, estimation of the reserve is most done based on the outcrop area and approximation. The total area of outcrops is 300 thousand m^2 and the amount of reserved perlite is estimated to be 11 million tons (Fig. 3).

Fig. 3. Active Ajmi Mine.

Ablack perlite reserve

This reserve is located 30km away from southwest of Mianeh and 800 m away from Tabriz-Tehran Railway. The access to its location is possible through second-grade soil covered road of Mianeh-Hashtrood. This reserve is mostly composed of grayish perlite theoutcrops area of which amounts to 150 thousand m^2 and its relative amount of reserve is estimated to be 14 million tons.

Tushmanlu and Sidler perlite reserve

This reserve is located 76 km away from Mianeh Town the access road to which is of first-grade type. The tests and analyses of samples on this reserve denote that its quality is similar to ShirinBalagh Reserve. This reserve covers an area of 500 hectares and it is estimated to contain 138 million tons of perlite.

Sefid Khane perlite reserve

This reserve is 35km away from south of Mianeh in an ally called SefidKhane. The perlite of this area is associated with Miocene volcanic activities and the volcanic phase starts from tuff and ends with hyalodacite-andesite. This sequencehas outcropped in north, northwest, and west of Mianeh. The bottom part includes tuff and the top part is made of acidic magmas (Fig. 4).

Genesis of Perlite Reservoirs in Middle Cenozoic Zone

In the studied area, most of the existing rocks are made of trachyte, trachyteandesite, and low levels of rhyolite. In desert, the surficial parts of perlites whiten due to weathering. These surficial parts represent clay minerals which are often of kaolin type. When the surficial parts are removed, the normal perlite becomes visible. This type of perlite is called “volcanic hydrous glass” which is general made of rhyolite compounds. This term also refers to lightweight aggregates made due to expansion of glass and after grinding and graining. From petrologic viewpoint, perlite is recognized as a glassy rhyolite with pearl-like luster, concentric fractures, and onion-like layers. The development of perlite is usually limited to tertiary and quaternary parts of rhyolitic belts.

Fig. 4. Active SefidKhane Mine.

Geology of Perlite Reservoirs in Middle Cenozoic Zone

Oligomiocene

From lithological perspective, Oligomiocene includes a set of conglomerate rocks with middle layers of sandstone and local red - red brown marl. All pieces of this conglomerate is made of Eocene and Oligocene rocks which are uncomfortably placed on the older units. The conglomerate elements were made completely spherical the size of which ranges from few centimeters to 40 cm.

Miocene

This unit has acidic composition with grey and red quartz, feldspar materials combined in magmatic and sectional manner. In this unit, a sequence of Sedimentary rocks including conglomerate with volcanic components and sandstones made of acidic

volcanic tuffs is observed. The continuation of this unit toward west and beyond the unit limits is mostly made of volcanic sands with middle layers of lime. The lime samples of these unit host certain fossils dating back to early (lower) Miocene era. The conglomerate parts are mostly volcanic rocks of Eocene era such as andesite, trachyandesite and numerous dykes of dark green color. These dykes have porphiritic texture with plagioclase, pyroxene and to less extent quartzite crystals. The texture of the rock is mostly made of plagioclase microlites decompose into secondary clay, carbonate and chlorite materials.

Another structure marked in "Mri" abbreviated name is evident in the area which is below the top unit. It is mostly made of rhyolite, rhyodacite and in some areas Ignimbrite. The volcanic rocks of this unit often have a layering system which represents regular volcanic activities in the region and the mineral material of perlite exists in this unit. The lithological samples of this unite represent a glassy texture made of recrystallized quartz and feldspar. In some samples, a glassy texture is observed in the section of circular fractures. These rock have some fractures and holes mostly filled with smoke-colored quartz. Biotite is the only mineral that is visible to naked eyes. Quartz is observed in secondary and shapeless manner. The secondary minerals mostly made of decomposition of feldspars include clay-carbonate and chlorite minerals. Small parts of rhyolite are altered locally, especially in contact with perlites, along small fractures and change into white soft soils. The products of alteration are mostly layered minerals such as kaolinite and to insignificant extent, montmorillonite.

Another unit marked with the abbreviate "Mpe" includes perlites which constitute main objective of present study. The perlite rock is located in the region, inside rhyolites and with colors ranging from blue-green to black. In some areas, the perlite has layering and shows 18 degrees of northward slope. In manually collected samples, the margins of perlites had been surrounded with iron oxides and the widespread red spots were completely visible among perlite glasses. The younger-than-Miocene units include dark-colored volcanic rocks which are of shear type in bottom part and represented by PIb.

The top part of this unit includes magma and it is represented by Pla. A major part of northern limits is covered with andesite and dark-colored andesite rocks. In the east and beyond the volcanic limits, this unit covers marl-sandstone sedimentary units of Miocene era. As a result, it is younger than Miocene units and because it is mostly made of volcanic rocks without shale, it is attributed to Pliocene era from stratigraphic viewpoint. The destruction of these rocks is done like onion skins.

From microscopic viewpoint, it is made of a fine-grained texture with definite pyroxene crystals of dark colors. In this regard, the microscopic sections showed a porphyritic texture with pyroxene phenocrystals and alkali feldspars. The plagioclases range from shaped to semi-shaped ones with basic composition. Sometimes, some margins of alkali feldspars are meagerly.

The pyroxene crystals are mostly shaped the size of which ranges from 1 to 4 cm. The texture of the rock is mostly mad of feldspar and pyroxene. The secondary minerals made of texture decomposition are mostly chlorite, sericite and clay minerals.

Quaternary

The structure of these unitsis made of shallow lake sediments consisting of Silt, tuff, sandy tuff, silty clay and pumice. The main outcrop of this unit is limited in west, center and southwest which horizontally cover the older rocks. A number of clay sediments are observed toward the west and beyond the bottom limit of this unit, which are equivalent with Sahand fish-bearing deposits. This phenomenon shows that the surrounding area of Sahand continued to this region in polio-quaternary era. In addition, the sedimentary deposits made of destruction and

washing off existing regional rocks of different type mostly cover agricultural regions and observed at the bottom of those rivers and streams that mostly contain sand, stone and gravel.

Chemical Composition and Mineralogy of Mid-zone Perlite

Under the term "perlite", two relatively different samples are recognized.

The first type is the natural one. It refers to any naturally made stone. In fact, it is a volcanic hydrous glass with rhyolite combination for which the value of water ranges from 3 to 5 percent. The andesite and dacitepelites are also found in nature but they have economically negligible value. Of course, the distinctive characteristic of all volcanic glasses is containing significant amount of structural water. Obsidian might contain 1% (or less) water and pitchstone might have up to 10% water. In the middle of these two, there are pumice and perlite (Fig. 2).

The second type is a lightweight aggregate which is artificially manufactured. In this regard, perlite is initially grinded and then, passed through some screens for graining. The fine-grained product is heat at 700-1200 °C. As a result, the water steam and blocked-in volatile gases are released and a delicate porosity is made in the perlite. The resulting lightweight, white and voluminous mass is called expanded perlite. The constituting elements of the structure and composition of this perlite contribute to its expansion. In this regard, combined and structural water contained play the most significant roles because fore turning into stream, they contribute to softening of the glace and with resumption of heating, the pressure made by sudden outrush of water steam expands the perlite.

The quality of the mineral material shows that in average, it contains 5 percent structural water. The mineralogical composition of perlite sample is represented in table 1.

Table 1. Chemical Analysis of a Sample of Perlites of Mianeh Zone-Dash-Atan Region.

SiO2	AL2O3	Fe2O3	CaO	Na2O	K2O	H2O
72.83	13.84	1.03	0.5	2.7	4.55	5.1

Different Types of Perlite in Middle-Cenozoic Zone

In this section, a summarized discussion of different types of perlite is done because the texture type in perlite represents its economic value and development. Therefore, three types of perlites have been defined. The development of different textures of perlites depends on placement depth so that in the external part of rhyolite dome, the perlite texture is made of pumice and the sizes as well as graining increase inward while the texture density rose. As a result, one gets to the internal part that is the rock core (fig. 3). Toward the inside, pumice, granular and clastic textures are distinguishable.

Types of Perlites in East of Iran

But in east of Iran, a series of perlite resources have been identified among which one could point to the following.

Perlite Reservoirs of Birjand Region

In all reservoirs of this region, the more we progress to higher depth the higher quality the samples have. It seems that this issue is completely associated with their level of water because the presence of 2-5 percent of combined water contribute to significant increase of volume of samples during heating. The studies of thin sections of regional perlites show that they are made dacite-rhyolite from petrographic viewpoint.

Based on first works done in Birjan Region, valuable resources of perlite were identified in Sar Bishe Region one of which is a perlite mine located 10km away from northwest of Sarbishe. The discovery step has finished and now, it's time of exploitation. In addition, another good reserve of perlite was found in northeast of Bishe and near Gangan Village.

The west of Birjand has a very thick horizon of perlite and glass tuff. These horizons have numerous outcrops in north and northwest of Iran. At the bottom of this horizon, there is a green tuff and right above it, there are Eocene rhyolites and Ignimbritea.

In the southeast of Birjand and near to Sarbishe, there are valuable reservoirs of perlites shaped in lens- and band-like forms inside a basin of Upper Eocene- Oligocenevolcanic rocks. The volcanic rocks which surround perlites are mostly of dacite, dacite andesite, and above-dacite types.

In general the volcanic activity in southeast area of Birjand dates back to Upper Eocene- Oligocene era and in most of the parts, the acidic composition has an intermediate range as a result of which the formation of perlite in this region. The proof to this claim is the perlite mines. The perlites of the region are of dacite-rhyolite type from petrographic perspective. The younger the perlites are, the higher quality they have. In addition, the quality of samples increases from surface to the depth.

In southern areas of Khorasan with insignificant level of water resources and agricultural activities, mineral reservoirs and their associated industries are highly attended. Due to the possibility of formation of perlite resources in the region and their applications in different industries, the discovery of perlite in the region seems to be essential. To prevent the loss of significant capital for transportation of perlite to factors that manufacture expanded perlite, the establishment of factory to produce expanded perlite in the vicinity of perlite mines of the region is recommended.

Sarbishe perlite

The Sarbishe Pelite Mine is beside the main Zahedan-Birjand road, 10 km away from northwest of Sarbishe. The Gangan Perlite Mine is also in the northern and northwestern limits of Gangan Village and about 15 km away from northeast of Sarbishe. From geological position, the Sarbishe Region that includes the perlite reservoirs discussed in the present study is located in northern part of Sistan Zone.

Other Indices of Perlite in Iran

Perlite in Gonabad Region

In addition to the above areas, the potentials of others areas, such as Barvishe, Bajestan, Tabas, as wells as Paleogene and Neogene areas, could be discovered and exploited in a cost-effective manner. In addition, there are perlite reservoirs in Sistan and Baluchestan Province as well as Nain and Kashan Towns.

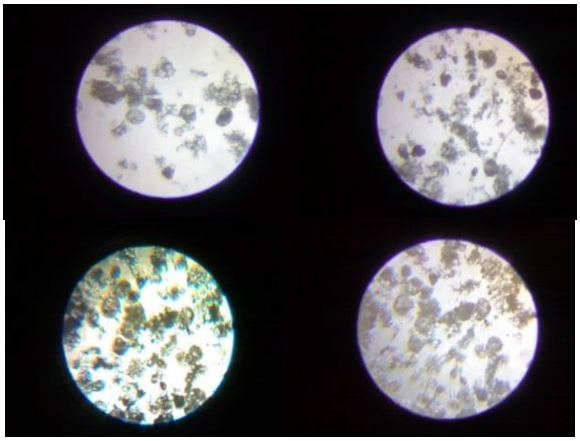

Fig. 5. Microscopic sections of four perlites sampled from studied zone (Right to Left: Dash Atan Perlite, Ashlagh Chai Perlite, SefidKhane Perlite and Ajmi Perlite).

Fig. 6. Samples of raw and expanded perlites from DatashAtan Mine (a: aggregate perlite; b: raw perlite with size of 2mm, c: raw perlite with size of 4.1mm, d; raw perlite with size of 0-5.1mm, e:expanded perlite with size of 2.5mm, f: expanded perlite with size of 1.5mm).

Conclusion and Further Suggestions

Most of the high-quality perlites belong the Third and fourth geological eras. The distribution of perlite in Iran has been reported in southwestern regions on Paleogenevolcanic rocks, Se-Chankagi Area, Azerbaijan Area especially Mianeh Town, east of Iran such as Gonabad, Ghaen, as well as vicinities of Birjan, Ferdos and Tabas along with Sistan and Baluchestan Province such as Nain and Kashan Towns. Most of the high-quality perlites of Cenozoic Zone studied are associated with Miocene era and were discussed in the present study. These perlite rocks range from green-blue to black in color and are located inside rhyolites. The variance of grade of useful elements with SiO_2, Al_2O_3, K_2O, Na_2O, H_2O and harmful elements accompanying Fe_2O_3 and free silicate in its saturated and secondary forms are respectively permissible up to 2, 1, 0.25, 0.15, 1, 0.2 and 53 percent. The previous studies show that the tectonic movements are highly significant in the studied zone in the boundary of Miocene and Pliocene. The major volcanic activities of polio-quaternary area along with activities of numerous faults that even sliced the alluvia of present era represent the activeness of this zone in Cenozoic and present eras. Due to possible development of perlite resources in the area and widespread applications of this material in different industries, the discovery of perlite in the region is an essential issue. To prevent the loss of significant capital for transportation of perlite to factors that manufacture expanded perlite, the establishment of factory to produce expanded perlite in the vicinity of perlite mines of the region is recommended.

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