Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print), 2222-3045 (Online)
http://www.innspub.net
Vol. 6, No. 2, p. 417-422, 2015

INNSPUB

RESEARCH PAPER OPEN ACCESS

The study of heshmat abad's kaolin based in jirandeh (Rudbar, Iran) Quadrangle (1:100000-scale)

Saied Naimi*, Fateme ghotb tahriri, Mostafa Baratiyan, Ebrahim Nazemi

Department of Geology, The Science College, Islamic Azad University, North Tehran Branch,Tehran, Iran

Key words: Rudbar, Alborz, Alteration, Fault, Green strength, Firing test, Nacrite.

Article published on February 09, 2015

Abstract

Kaolin deposit of Heshmat Abad in south Rudbar, is situated in Alborz zone. This deposit is like an alteration zone with thickness of 10 meters which has a fault zone outcrop trending the northwest-southwest. Based on petrographical studies the host rock contains vitric Tuff crystal mineralization with rhyolitic composition which belongs to the middle Eocene. Kaolin is created due to alteration of glass tuff argillic which is witnessed in two consecutive generations: first generation made by alteration of feldspar crystals in host rock and second generation fills the seams of the rock in form of veinlets and veins. Based on deposit studies, the main mineral phases include quartz, kaolinite and nacrite. Chemical studies showed that the deposit of Heshmat Abad is very similar to the deposit of Sabzevar and Zonuz. Considering the results of strength raw test of area samples, Kaolin from this mine can be used as a filling industrial soil in the body formula of ceramic tiles.

***Corresponding Author:** Saied Naimi ✉ saeednaemi38@gmail.com

Introduction

Kaolinite is a clay mineral, part of the group of industrial minerals, with the chemical composition $Al_2Si_2O_5(OH)_4$. It is a layered silicate mineral, with one tetrahedral sheet linked through oxygen atoms to one octahedral sheet of alumina octahedra Rocks that are rich in kaolinite are known as kaolin or china clay. Kaolinite clay occurs in abundance in soils that have formed from the chemical weathering of rocks in hot, moist climates—for example in tropical rainforest areas. Comparing soils along a gradient towards progressively cooler or drier climates, the proportion of kaolinite decreases, while the proportion of other clay minerals such as illite (in cooler climates) or smectite (in drier climates) increases. Such climatically-related differences in clay mineral content are often used to infer changes in climates in the geological past, where ancient soils have been buried and preserved.

Fig. 1. The Kaolin Deposit of Study.

Fig. 2. The geological 1:50000 map of Heshmat Abad.

Heshmat Abad's Kaolin deposit is located in the south Rudbar, 30 km far from the southeast Rostam Abad between geographical lengths 70", 37', 49° and 13", 42', 49° 'E and latitude 48', 36° and 50', 36° North (fig. 1). The case study area is part of Alborz zone in division of structural zoning of Iran (Stocklin, 1968) and according to Engalenc's study (1968) is situated in center treasure zone (Engalenc). From geological perspective area of case study is part of Jirandeh slab with 1.100000 scale which according to map of 1:50000-scale related to Heshmat Abad area (GSI, 2002). Two rocks units can be seen in the area including: carbonate unit which based on map with 1:50000 scale of the study area contains limestone with medium and high thickness layers which forms a gray-colored mass where locally there are black chert nodules in its layers.

The age of this unit dates from upper Jurassic. The second unit is Lava and pyroclastic units, with gray to dark gray color on the ground and according to map 1:50000-scale the age of the study area dates from Early-Middle Eocene. Based on petrographic studies, this unit in contact with the Kaolinite unit of area has rhyolitic tuff composition (fig. 3). This area's Kaolinites in the form of alteration zone with about 10 meters thickness is located in fault zone outcrop trending northwest-southeast. Eastern boarder of it which is in contact with carbonate unit belongs to *Late Jurassic–Cretaceous or Early and its western border comprises* igneous rocks and Eocene pyroclastics.

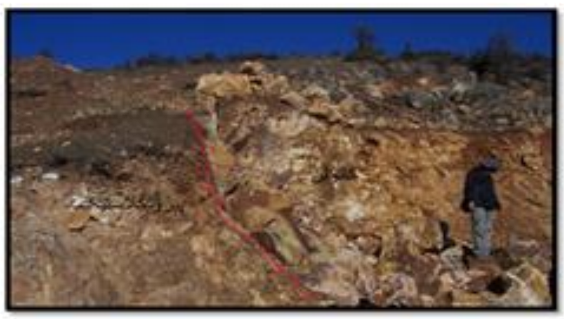

Fig. 3. Contacting carbonate units with igneous rocks and area's pycroclastic.

To obtain green strength and sample firing, pieces of raw material were formed like a ruler, then they were kept in drying for 24 hours at the temperature of 100°

c, next they were fired in the temperature 1300° c temperature, the temperature which is based on material composition (silica). The firing operation was carried out at heating growing rate of 5° C per minute with duration of 2 hours. After the end of firing, samples gradually cooled to the ambient temperature, and then using flexural strength testing machine the pieces were measured. Measuring using flexural strength testing was done with 10 cm distance between straddles based on the three point approach and one-time fixed imposing from above at 0.05 mm/s speed rate. The rate of imported forces for breaking pieces was read according to the machine order and it was imported into three-point formula. The main objective of the present article was Study of Heshmat Abad's Kaolin Based in Jirandeh (Rudbar, Iran) Quadrangle (1:100000-scale) and define the Geochemistry and Mineralogy of rocks in this area.

Material and methods

The area under study

The case study area is part of Alborz zone in division of structural zoning of Iran (Stocklin, 1968) and according to Engalenc's study (1968) is situated in center treasure zone (Engalenc). From geological perspective area of case study is part of Jirandeh slab with 1.100000 scale which according to map of 1:50000-scale related to Heshmat Abad area (GSI, 2002). Two rocks units can be seen in the area including: carbonate unit which based on map with 1:50000 scale of the study area contains limestone with medium and high thickness layers which forms a gray-colored mass where locally there are black chert nodules in its layers.

Sampling and analytical method

During the field observations was collected of 100 rock samples from all parts of the study area. After studying the manual sample, 50 thin section preparation and was studied with petrographic polarizing microscope. Some of the fresh rocks selected for ICP-MS and XRF analysis. The analyses were made in Acme Laboratory in Canada (Table 1,2,3,4,5).

Table 1. The Result of chemical analysis on Area's Kaolin and Tuff.

Samples area / Acid composition	S-H-3 Tuff	S-H-5 Kaolin	S-H-10 Kaolin	S-H-11 Kaolin
SiO_2	64.73	79.77	76.01	77.77
Al_2O_3	13.64	14.29	15.82	15.06
CaO	4.99	0.09	0.05	0.08
Fe_2O_3	4.8	0.15	0.56	0.16
K_2O	0.76	0.03	0.02	0.02
MgO	0.32	0.03	0.02	0.02
P_2O_5	<	<	0.15	0.11
SO_2	<	0.07	0.14	<
TiO_2	0.56	0.73	0.78	0.74
LOI	9.33	05.43	6.41	5.95

Results and discussions

Petrography

Based on petrographic studies, mineralization host rock has rhyolitic composition with clastic Vulcan texture and generally comprises of the shards of glass, quartz and some feldspar crystals. Stone matrix, as well, has suffered devitrification. *Also, in some samples of feldspars completely alternated and* Kaolinized are embedded in altered glass matrix. Due to Kaolinizing, this matrix transformed to quartz and Kaolinite (fig. 4).

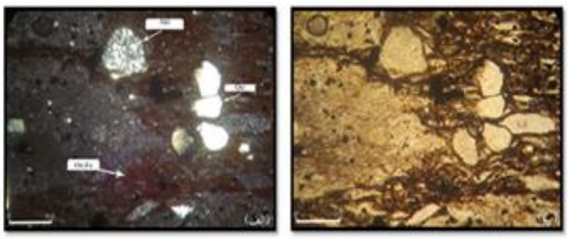

Fig. 4. Davitrification of Vitriv Tuff Crystal.

Kaolin mineral in these samples has been seen in two generations. The first generation created resulting from alteration of host rock's feldspars (fig. 5), but the second generation of Kaolinits in the form of small and large vinelets and vine cuts host rock and fills the cracks of the rack (fig. 6).

Geochemistry and Mineralogy

According to X-ray diffraction (XRD) analysis, the dominant phase is quartz in the form of silicon oxide and a small amount of nacrite, kaolin, and minimal dickite are also included. The result from the *X-ray*

Fluorescence (XRF) of three kaolin samples and one sample of tuff host rock is available in Table1. As is expected from XRF result, in kaolin chemical composition there are much reduction compared with tuff; for example K_2O 67% in tuff reduces to .02% in kaolin, Fe_2O_3 4.8% in tuff to 16% in kaolin, CaO 4.99% in tuff to 0.08% in Kaolin.

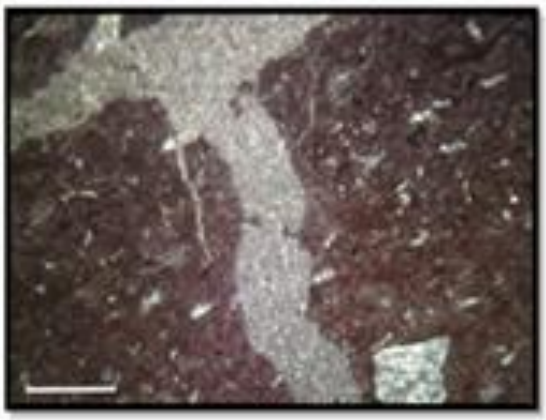

Fig. 5. Kaolinization of a feldspar crystal.

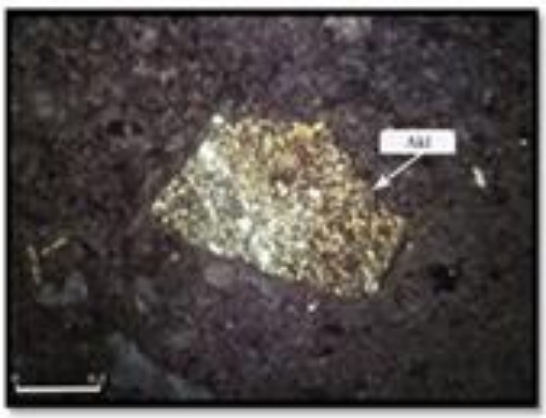

Fig. 6. Kaolin Minerals in Form of Vinelets and Vine Cut the Host Rock.

The amount of SiO_2 in kaolin is increasing from %64.73 to %77.77 and the amount of Al_2O_3 in tuff is on the rise from %13.64 to %15.06 in kaolin. TiO_2 in kaolinite sample is similarly increasing while the amount of MgO in tuff is decreasing from %0.32 to %0.03 in kaolin. In order to compare chemical composition of under-study kaolin with best known kaolin of country we used SiO_2-Al_2O_3-Fe_2O_3triangular diagram. This diagram shows the state of kaolin samples in the under-study area in comparison with kaolin of Zonuz, Alangeh, and Sabzevar mines.

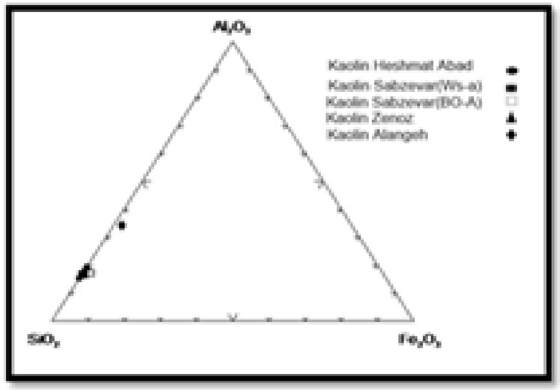

Fig. 8. Position of the Study Area's Kaolin Samples Compared With Sabzevar, Alangeh, and Zonuz Mines.

As shown, the area's kaolin samples are largely similar to thosefrom Zonuz, Alangeh, and Sabzevar mines (fig. 7). As can be discerned from the SiO_2-Al_2O_3-LOI diagram, the under-study samples completely coincide with kaolin of Zonuz, Alangeh, and Sabzevar mines (fig. 8). The conducted analysis in below diagrams indicates the comparison between main oxides of the known kaolin mines of the country with Heshmat Abad mine in Rudbar. As can be shown in chemical and chemical composition diagrams, we compared available kaolin with kaolin of Zonuz, Alangeh, and Sabzevar mines (Karim pouram, 1999). The main oxide chemical composition of Zonuz kaolin is averaged and shown in Table2. The amount of silica extracted from Heshmat Abad's kaolin was the highest among the analyzed samples and the highest compared with the rest of the mines. Also, the amount of alumina (Al_2O_3) from Alengeh mine was the highest. Although comparing the amount of this oxide with the under-study kaolin don't show significant difference, still Zonuz mine and Heshmat Abad S-H-11 mine samples were at the next level and Sabzevar mines samples and Heshmat Abad's S-H-5 were at the last level. The highest amount of iron oxide (Fe_2O_3) belonged to Alengeh mine and the amount of kaolin from other mine don't show significant difference in comparison with the amount of fe203 available in Heshmat Abad kaolin. Table 3 illustrates the comparison between the main oxide available in Heshmat Abad kaolin and kaolin of Georgia and Cornwall England which are among the most important kaolin reservoirs in the world (Hemsteger, 1926).The amount of Aluminum from the under-study area having kaolin (Heshmat Abad-Rudbar kaolin mine) was 15.82 percent that, compared with kaolin of Georgia and Cornwall England at 38.38 and 37.79 respectively is at the lowest possible level which is long way from ideal composition of kaolin (Al_2 = %39.5). In addition, the amount of silica oxide in the under-study kaolin is more than Georgia and Cornwall England. Generally, Iran's clay kaolin soil contains more percentage of Al_2O_3 and less percentage of SiO_2 comparing with typical reserves of kaolin, as is obviously visible in fig.s 2 and 3. The greatest amount of TiO_2 belongs to Georgia kaolin and the two kaolins of Heshmat Abad and Cornwall are in lower levels.

Table 2. The Result of chemical analysis on Area's Kaolin and Tuff.

Sample	SiO_2	Al_2O_3	CaO	Fe_2O_3	K_2O	MgO	MnO	NaO	P_2O_5	SO_2	TiO_2	LOI
S-H-5	79.77	14.29	0.09	0.15	0.03	0.03	-	-	0.12	0.07	0.73	5.43
S-H-11	77.77	15.82	0.08	0.16	0.02	0.02	-	-	0.11	0.03	0.74	5.95
Sabzevar (WS-a)	75	15	0.2	0.3	2	0.2	-	0.2	-	0.1	0.4	5
Sabzevar (BO-A)	70	15	0.15	0.15	7	0.8	-	0.15	-	0.1	0.8	5
Zenoz	73	17	1.8	0.17	0.13	0.32	-	0.3	-	-	0.03	7
Alangeh	54	29	0.19	2	0.16	0.14	-	0.29	-	-	1.2	11

Table 3. Comparing main oxide of Heshmat Abad Kaolin with Georgia and Cornwall Kaolin.

Percentage of main oxide	Heshmat Abad-kaolin	Georgia-kaolin	Cornwall-kaolin
SiO_2	77.7	45.3	46.77
Al_2O_3	15.82	38.38	37.79
CaO	0.08	0.05	0.13
Fe_2O_3	0.16	-	-
K_2O	0.02	0.04	1.49
MgO	0.02	0.25	0.24
MnO	-	-	-
$Na_□O$	-	0.27	0.05
P_2O_5	0.11	-	-
SO_2	0.03	-	-
TiO_2	0.74	1.44	0.2
LOI	5.95	-	-

Table 4. The Green Strength test Result of Heshmat Abad's Kaolin sample.

Green sample Number	Green strenght Kg/cm²)
1	42
2	46
Average	44

Table 5. The Firing Strength test Result of Heshmat Abad's Kaolin sample.

Sample Number	Green strength (Kg/cm²)
1	678
2	690
3	518
4	514
Average	600

Green Strength and Firing Test

To obtain green strength and sample firing, pieces of raw material were formed like a ruler, then they were kept in drying for 24 hours at the temperature of 100° c, next they were fired in the temperature 1300° c temperature, the temperature which is based on material composition (silica). The firing operation was carried out at heating growing rate of 5° C per minute with duration of 2 hours. After the end of firing, samples gradually cooled to the ambient temperature, and then using flexural strength testing machine the pieces were measured. Measuring using flexural strength testing was done with 10 cm distance between staddles based on the three point approach and one-time fixed imposing from above at 0.05 mm/s speed rate. The rate of imported forces for breaking pieces was read according to the machine order and it was imported into three-point formula. The result of green strength and firing test can be seen from figs. 4 and 5.Because of the limited amount of flour, 6 samples including 2 green samples and 4 firing samples were measured. The firing strength standard value based on Institute of Standards and Industrial Research of Iran has been defined more than 225 kg/cm. Although in industrial scale, the value higher than 350 to about 600 are also available.

Based on the average 600 kg/cm taken from the under-study area kaolin samples, it can be concluded that kaolin of this mine respecting strength of firing lives up to the standard in industrial scale. The high firing strength of under-investigation mine is regarded as a positive and efficiency factor the kaolin of which can be used as appropriate filling industrial soil in body formula of ceramic tile.

Conclusion

Heshmat Abad kaolin deposit is located in south Rudbar, 30 km far from the southeast Rostam Abad, in Alborz zone. Based on geological studies the host rock composed of crystal igneous tuff with rhyolitic composition is specified in relation to Middle Eocene in 1:100000-scale Jirandeh map. According to petrogrphic studies, two generations of kaolin are available in the area: the first generation of kaolin created by alteration of feldspar, and the second generation of kaolin in the form of vinelet and vine filling cracks of host rock.In comparison with kaolin in Sabzevar, Zonuz and Alengeh, kaolin composition has approximately same amount of silica and alumina. In addition, comparing Heshmat Abad's kaolin with Georgia and Cornwall England showed the under-study kaolin reservoir (Heshmat Abad-Rudbar kaolin mine) had far less amount of aluminum about 15.82 percent in contrast with that of Georgia and Cornwall England with 38.38 and 37.79 percent respectively, and shows a considerable distance from the ideal composition of kaolin (Al_2O_3) that is 39.5 percent. The analysis of physico-mechanical tests showed that the high firing strength was at level of industrial scale and therefore it can be used as appropriate industrial filling soil for using in ceramic tiles.

References

Engalenc M. 1968. Geologie, geomorphologie, hydrogeology de la region de Tehran (Iran).Theses sciences . Monpellier.

Engalenc M. 1968. Geologie, geomorphologie, hydrogeology de la region de Tehran (Iran).Thesees sciences . Monpellier, 180

Ghalamghash. 2003. 1/100000 map of Jirandeh, Geological Survey of Iran.

Hemsteger SE, Stief WC. 1926. The use of Georgia and North Carolina kaolins in a semiporcelain body. Journal of the American Ceramic Society, **9(7)**, 444-445.

Hemsteger SE, Stief WC. 1926. The Use Of Georgia And North Carolina Kaolin In A Semiporcelain Body". Journal of the American Ceramic Society, **5**, 444-445.

Karim Pour MH. 1999. Industrial minerals and rocks , Ferdowsi University Press..

Karimpour H. 2000. minerals and industrial rocks (new edition), publication of Ferdowsi university.

Qlmqash. 2002. Jirandeh 100000/1-scale Map. Geological Survey of Iran.

Stocklin J. 1968. Structural history and tectonic of Iran: A review. American Association of Petroleum Geologists Bulletin, **52(7)**, 1229-1258.

Stocklin J. 1968. Structural history and tectonic of Iran:a review, American Association of petroleum Geologists Bulletin,vol. **52(7)**, 1229-1258.