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GEOLOGY AND UTILIZATION OF PEGMATITIC ALBITITES AND APLITES OF MANSEHRA AREA, NWFP AS INDIGENOUS RAW MATERIALS FOR POTTERY WARES

M. Ayub, M. Yusaf, Sherjil A.K. Lodhi and Mohammad Ashraf*

PCSIR Laboratories Complex, Lahore-54600, Pakistan

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Various samples of pegmatitic albitites and aplites were collected from Mansehra area of NWFP of Pakistan. It was found that only pegmatitic albitites, albite aplites and albite-microcline aplites were the rocks suitable for making pottery wares. For this purpose petrographic and chemical analysis were carried out. The crushed samples were used for the purpose of making porcelain bodies as well for glazes to be used on their respective bodies. The presence of small quantity of TiO_2 and Fe_2O_3 was successfully used to impart cream to orange cream colour to both bodies and glazes. The studies were carried out to replace conventional feldspar totally and quartz partially.

Key words: Pegmatitic albitites, Aplites, Pottery wares.

Introduction

Large quantities of feldspathic rocks are known from Mansehra and Batgram area. The feldspathic rocks are present in various forms, as pure albitites [1], aplites, pegmatitic albitites and albitized rocks [2]. These rocks are emplaced in granites and metamorphics of Hazara district [6] (Fig. 1). The granites and metamorphic rocks have been described by Shams [3,4]. The quartz veins are present in the area as thin and sizeable bodies, which are also being used for pottery making.

Materials and Method

Geology of feldspathic rocks. The feldspathic rocks occur in the form of albitites and pegmatitic-albitites and they are fine to medium in grain size. The aplites occur mainly as albite-aplites-pegmatites, albite-microcline-aplites-pegmatites. The aforesaid rocks are abundantly present as lenticular branching and as tabular bodies. The usual size of these bodies is 2 - 10 meters in width and 4 - 70 meters in length and are present along the foliation planes of granites, particularly along Mansehra granite. These bodies occur as independent and at some places composite with each other. These rocks are present in Mansehra district in the following localities: Attarshisha, Phagla, Lassan, Manglour, Chitta Batta, Mairaj Ali, Seri, Batrasi, Jaba and Sandasar. All the deposits are accessable by a good metalled road. Private transport is available in the investigated area. The reserves of the feldspathic deposits are estimated in millions of tons. The contacts of these pegmatitic bodies with host and associated rocks is very sharp, which show that the material has hardly been exchanged across.

* Institute of Geology, AJK University, Muzaffarabad, Azad Jammu & Kashmir.

Petrography

Owing to different texture and mineralogy the petrography of both types is described separately as:

Pegmatitic albitites. The grain size is usually 1 - 5 mm in most cases. These bodies are not fairly homogenous due to random distribution of the grain size in them. They are white looking rocks with a few specks of darker grains.

In thin sections, the albite are ranging from 1.5 to 6 mm in size. The finer grains are of quartz, sphene, muscovite, apatite etc. The model composition shows the rocks consist of mainly around 70 - 80% (Table 1). The minerals present in these rocks are described as follows:

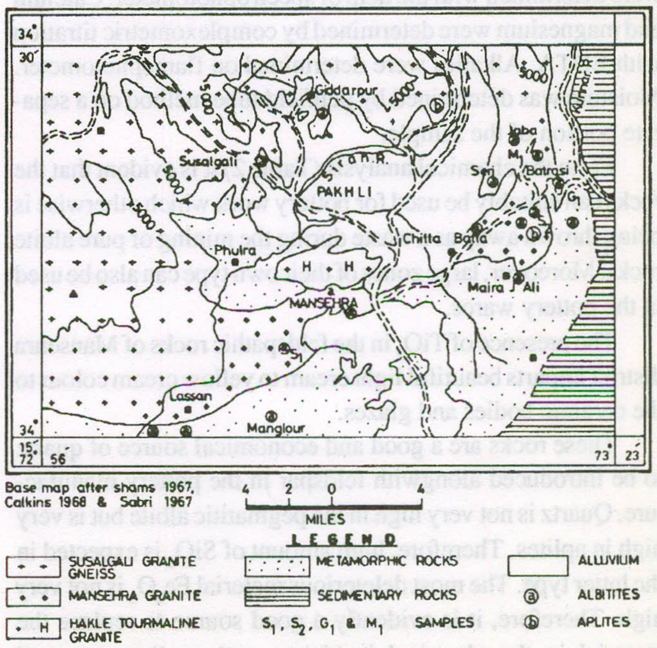

Fig. 1. Geological map of Mansehra area, Hazara district showing location and distributions of albitites and aplites.

The grain size of albite usually ranges from 2.5 to 6.5 mm with a few grains ranging from 1.5 - 2mm, with the composition An 2.5 - An6. The twinning is according to polysynthetic, carlsbad and chess-board laws. It constitutes 70 - 80% of the rock. It alters a little to sericite and kaolinite. Quartz is usually 0.4 - 1 mm in size as individual grains and as aggregate of the finer grains. Muscovite is present in the form of needless and flakes and varies in size from 0.1 - 0.8 mm. Sometime it is enclosed in feldspar. Sericite is an alteration product of albites. The size of the sericite is so small that it can not be measured. Biotite is less than 0.05 - 0.5 mm in the form of tablets and needless. It is light to light brown in colour. Sphene occurs as dusty grains but usually coarser grains upto 2.8 mm. Sphene shows brown and dark brown colour. Rutile is closely associated with sphene in the from of brown to dark brown needless. Apatite occurs as very fine grains. Chlorite is present as fibrous radiating flakes in cavities about 0.1 - 0.3 mm in size.

Pegmatitic aplites. These are fairly uniform rocks having grain ranging in size from 1 to 1.5 mm. They are greyish white to white in colour and are mildly sheared to strongly mylonized rocks. Albite and quartz are the dominant minerals with accessories like microcline, tourmaline, biotite, muscovite, apatite, sericite and sphene.

These accessories have the same optical features as those in pegmatitic albitites but are fine grained in nature.

Chemistry. Representative samples of various rocks were ground to very fine powder. Chemical analysis was carried out by standard methods of silicate analysis [5]. SiO_2 and R_2O_3 were determined gravimetrically. TiO_2, Fe_2O_3, MnO and P_2O_5 were determined with the help of spectrophotometer. Calcium and magnesium were determined by complexometric titration with EDTA. Alkalies were determined on flamephotometer. Moisture was determined by penfield tube method on a separate portion of the sample.

From the chemical analysis (Table 2) it is evident that the rocks can suitably be used for pottery work which otherwise is being thrown away as a waste during the mining of pure albite rocks. Moreover, large zones of their own type can also be used in the pottery wares.

The presence of TiO_2 in the feldspathic rocks of Mansehra district imparts beautiful light cream to yellow cream colour to the ceramic bodies and glazes.

These rocks are a good and economical source of quartz to be introduced alongwith feldspar in the pottery manufacture. Quartz is not very high in the pegmatitic albite but is very high in aplites. Therefore, high amount of SiO_2 is expected in the latter type. The most deleterious material Fe_2O_3 is not very high. Therefore, it is evidently a good source to replace the material in the electrical insulators and medium to good quality pottery bodies.

PHYSICAL PROPERTIES OF CERAMIC BODIES

Fusion temperature. Fusion temperature of the rock samples as well as the formulated bodies were determined by preparing pyrometric cones and firing them at various temperatures according to a fixed firing schedule. Total firing time being 48 hrs. including 24 hrs. of cooling.

TABLE 1. RATIONAL ANALYSIS.

Mineral composition	S_1	S_2	G_1	M_1
Albite	64.49	77.35	83.00	30.0
Quartz	25.59	16.20	15.00	39.0
Muscovite	7.25	3.50	2.06	5.0
Apatite	0.27	0.74	0.85	
Biotite	-	-	-	1.0
Microcline	-	-	-	25.0

TABLE 2. CHEMICAL ANALYSIS.

Constituent	S_1	S_2	G_1	M_1
SiO_2	74.35	67.60	70.50	71.71
TiO_2	0.35	0.80	0.41	0.30
Al_2O_3	15.00	19.70	17.89	14.30
Fe_2O_3	0.45	0.50	0.35	1.08
MgO	0.32	0.40	0.56	0.80
CaO	1.10	1.19	0.98	1.30
Na_2O	5.50	3.60	7.50	5.30
K_2O	1.30	0.65	0.42	4.20
P_2O_5	0.15	0.20	0.35	0.15
H_2O	0.60	0.30	0.45	0.95
	99.12	94.94	99.41	100.09

0° – 900° in 10 hrs.
900° – 1000° in 6 hrs.
1000° – 1200° in 3 hrs.
1200° – 1350° in 3 hrs.
1350° – 1400° in 2 hrs.

For low temperature bodies, schedule was shortened to 36-40 hrs. and adjustment in the above schedule was made accordingly. In case of rock samples, cones were prepared after grinding the samples to pass 150 mesh. Gelatin was used to impart green strength to the cones for rock samples. Temperature observation were made with optical pyrometer as well as by composition with standard pyrometric cones. Fusion temperatures of rock samples have been reported in Table 3.

Firing shrinkage and porosity. Rectangular type test pieces were made and fired at temperature to determine the linear firing shrinkage.

The same pieces were used for determining the porosity. The firing colour of the pieces was noted. The collected samples of pegmatitic albitites and aplites were named a S_1, S_2, G_1 and M_1 (Fig. 1) and their physical properties were determined and are given in Table 3.

Ceramic bodies and glazes. Various bodies were formulated using 15 - 45% feldspathic rock, 50 - 80% pottery clay and 0 - 35% quartz. Bodies were mixed thoroughly in small pot mills. Bodies were deflocculated with the addition of sodium silicate and sodium carbonate. Test pieces were prepared in the form of small crucibles.

Firing. Electric furnaces as well as gas fired furnaces were used for firing the pieces to various temperatures. Electric furnace was used upto 1300° and the gas furnace was used for temperature higher than 1300°.

Formation of porcelain bodies. Four sets of ceramic body compositions using pegmatitic albites and aplites (S_1, S_2, G_1 and M_1) were formulated as shown in Fig. 2. in conjunction with quartz and pottery clay (Mianwali). Fig. 2 shows the compositions of the bodies 1 - 65 prepared in all the sets. The bodies were tested by the formulation of small crucibles, biscuit firing was carried out at 950° - 1000°. The biscuit pieces were fired after the application of glazes given in Table 4.

The temperature ranges between 1000° - 1250° for the softer bodies and from 1200 to 1400° for hard bodies.

TABLE 3. SOME PROPERTIES (PHYSICAL).

	S_1	S_2	G_1	M_1
Fusion temp.	1200°	1235°	1215°	1170°
Colour of the fired piece at 1200°	Cream	Yellow cream	Light cream	Greyish white
Porosity at				
(a) 1100°	8.50%	8.89%	8.30%	7.2%
(b) 1150°	1.50%	1.55%	1.30	1.02
(c) 1200°	Nil (0.002)	Nil (0.000)	–	Nil (0.000)
Firing shrinkage at				
(a) 1100°	Nil	Nil	Nil	1.3%
(b) 1150°	1.0%	1.5%	1.5%	5.5%
(c) 1200°	12.7	14.30	13.80	15.00

Composition area studied ranges:

Pottery clay = 40-90
Quartz = 0-50
Pegmatite = 10-65

Area of porcelain formation established after the thorough study ranges between the following limits:

Clay = 40-60
Quartz = 5-40
Pegmatitic samples = 20-50
(S_1, S_2, G_1 and M_1)

The area falling within points 5-3-9-41-44-5 gives softest bodies with G_1 pegmatite as compared to the bodies with S_1, S_2 and M_1. The hardest porcelain bodies, with G_1. Pegmatite withstand 1300° i.e., bodies No. 42 and 43. Bodies No. 7 and 8 fuse at 1150° and No. 4 at 1100°. The range covered by the

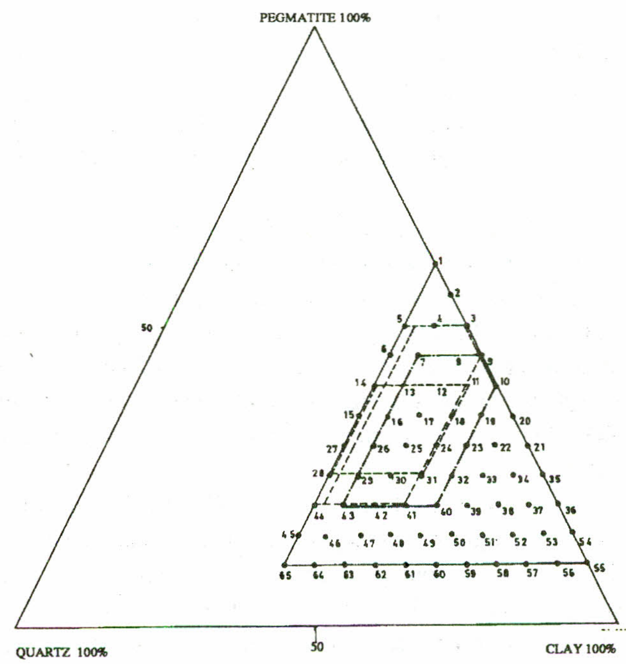

Fig. 2. Field of bodies composition.

TABLE 4. THE PORCELAIN BODIES COMPOSITIONS WITH GLAZES.

Glaze No.	1	2	3	4	5	6	7	8	9	10
Constituents of the glaze in %			S_2			G_1		S_1		M_1
Pegmatite	57.5	60.0	62.0	63.0	66.5	70.0	70.0	75.0	80.0	85.0
K.D. Pottery clay (China clay)	10.0	10.0	8.0	10.0	5.0	5.0	5.0	5.0	5.0	5.0
Marble chips	12.0	10.0	10.0	10.0	10.0	10.0	10.0	7.5	7.5	5.0
Zinc oxide	7.5	5.0	5.0	5.0	7.5	5.0	7.5	7.5	7.5	5.0
Quartz	10.0	15.0	13.0	12.0	10.0	10.0	6.5	5.0	—	—
Zirconium dioxide	3.0	—	2.0	—	1.0	—	1.0	—	—	—

area within 7-9-41-43-7 points are also soft and are formulated by M_1 pegmatite. Bodies with M_1 pegmatite form harder bodies with standing the firing temperature without deformation upto 1350° Approximately or nearby in the same area of study, i.e. bodies No. 42 and 43. These are harder than bodies with G_1 pegmatite. Body compositions No. 7 and 8 withstand 1200 - 1230°.

The area shaped by the lines joining points 14-11-31-28-14 are harder than the above two sets with S_1 samples. Body compositions with S_1 are still harder and withstand 1375°-1400°. Approximately in the same area than the bodies with G_1 and M_1. Bodies with S_1 numbering 7 and 8 withstand 1275°-1300°.

The hardest bodies are obtained by pegmatite S_2. The area being formed by the points 7-9-10-40-43-7 porcelain formed with S_2 in the same area, i.e., body No. 41 withstand 1450° and body No. 43 withstand 1460° without much deformation. Fusion cones with S_1 and S_2 do not bend sharply and the range is quite large. The composition S_2 samples numbering 7 and 8 withstand 1300° and 1350°.

Area lying above the line A-B in Fig. 2. forms softer bodies and area below the line gives harder bodies in all the four sets.

Temperature for deformation for softer bodies being less then 1275° and for hard bodies less than 1450°.

The firing schedule of the pieces for soft and hard bodies was maintained oxidizing reducing and oxidizing. The cycle was completed in 48 hrs. including 24 hrs. for cooling. The atmosphere being oxidizing upto 1000° and reducing between 1000° - 1250°, oxidizing upto 1350° and cooling to room temperature.

The colours of the bodies for S_1, S_2, G_1 and M_1, pegmatites varies from light cream to orange cream. Light cream to beautiful cream colour was obtained with S_1 and G_1 samples. The colour of the bodies made with S_2 and M_1 pegmatites were dark cream to orange cream. The colour imparted to the bodies were due to the presence of TiO_2 and Fe_2O_3 [7] in the pegmatites. The darker shade were obtained with samples, containing larger amounts of TiO_2 and Fe_2O_3 [7].

During this study the trials have been made to use these pegmatites for the replacement of feldspar and quartz partially in conventional porcelain bodies.

Glazes used for these pegmatites bodies also contain the same pegmatite as the fluxing component in the glaze batch. The glazes used are given in the Table 4. Firing range is 1200° for soft porcelain and 1370°-1425° for hard bodies.

Conclusion

This study was carried out to replace feldspar and quartz from the conventional porcelain bodies by pegmatitic albitites aplites and albite-microcline-aplites. The results are very encouraging. The feldspar has been replaced completely and quartz partially for both soft and hard bodies. All the four under study pegmatites can also be used in feldspathic glazes. Temperature rangs 1100 - 1400°, to suit the porcelain bodies under study. The presence of titanium and iron in the pegmatitic samples impart a beautiful cream colour in the porcelain bodies.

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