EXTRACTION OF HIGH QUALITY TALC FROM TALC-CARBONATE ROCK OF MINGORA EMERALD MINES BY FLOTATION AND LEACHING

Nisar Mohammad*, Mohammad Mansoor Khan*, Noor Mohammad*

ABSTRACT

Talc is hydrated magnesium silicate with chemical formula $Mg_3Si_4O_{10}(OH)_2$. In natural form pure talc is an extreme rarity and it is mostly associated with undesired minerals like magnesite, calcite, dolomite, quartz, muscovite, chlorite, tremolite and iron bearing minerals. These associated minerals determine the quality of talc for industrial purpose and if in access, limits its applications. In present research work, beneficiation studies of carbonatic talcose rock of Mingora emerald mine located in District Swat, Khyber Pakhtunkhwa (KP), Pakistan were conducted to recover high quality talc out of the talc carbonate rock and to develop a technique for up gradation of indigenous non-commercial talc resources from other locations. These rocks host emerald crystals and the debris are dumped after excavation and extraction of emerald crystals. Controll of environmental threat caused by these rock dumps is an additional benefit of the research. Two step froth flotation process with AF65 (Poly propylene Glycol, Cyanamid) as frother, Sodium hexa metaphosphate as depressant for carbonates, equal mixture of oleic acid and kerosene oil as collector gave encouraging results. It was found that talc can be separated as float at pH 6 - 7±0.2 in rougher flotation and 10 - 11±0.2 in cleaning flotation, depressant dosage 0.10kg/ton, and collector dosage of 1.2 kg/ton. Talc concentrate at recovery of about 60 - 70% with a grade of 92.50% from an ore containing about 50 to 70% talc was obtained. The final concentrate was treated with various leaching reagents. Dilute HCl (30%) + stannous chloride (300 ppm) gave better results. It reduced iron content from 4.37% in the concentrate to 2.89% in the final leached product and whiteness also improved up to 80% from about 51% of original talcose rock. Some tests were also conducted to improve whiteness of leached products but with little improvement in results.

KEYWORDS: *Talc, froth flotation, leaching, Swat emerald mine, beneficiation, Talcose rock*

INTRODUCTION

Talc is a secondary mineral formed by hydrothermal alteration of magnesium silicates like Olivine, Pyroxene, Amphiboles and Serpentine in the presence of carbon dioxide. It is also associated with low grade thermal metamorphism of siliceous dolomite, formed via reaction between dolomite and silica. Reaction between magnesium chloride and quartz also give rise to talc. The size, geometry and nature of the deposit depend upon the size and nature of parent rock and the intensity and scale of metamorphism. Tectonic movements also play a major role in talc formation. Earth movements allow the hydrothermal fluids to penetrate into mother rock, generate permeability that makes reactions inside the rock mass possible. The surrounding pressure either at the time of transformation or latter determine the talc lamerrarity.Talc deposits are classified into four types on basis of type of parent rock subjected to transformation and hydrothermal fluids penetrating the parent rock as derivatives of each of magnesium carbonate,serpentine, siliceous rocks and magnesium sedimentary deposits. Soapstone, steatite, pyrophylite, tremolitic talc and French chalk are the different varieties of talc. Depending upon its origin, talc is associated with undesired minerals like magnesite, calcite, dolomite, quartz, muscovite, chlorite, tremolite and other metallic/ iron bearing minerals. These associated minerals are hard and have abrasive effect if present in talc causing skin problems when used in cosmetic products. The metallic impurities like lead, arsenic etc have adverse toxic effects when used as drugs or if swallowed/ inhaled or used external on skin in the form of cosmetics. Some of the properties which make the talc valuable industrial commodity are its chemical inertness, high fusion point, lamellarity, softness, low thermal and electric conductivity, oil and grease absorption, fragrance retention, on- explosive and non-flammable behavior, high dielectric constant, whiteness, anti-sticking and Organophilicnes.

These properties make the talc applicable in diverse applications like palatynes and softness in cosmetic, paper and paints, inertness in pharmaceutical, pesticides,

*Department of Mining Engineering, University of Engineering and Technology, Peshawar, Pakistan

waste water treatment, hydophobicity in anti-caking and low thermal expansion in refractories etc.

Talc is an extremely versatile mineral with more than hundred uses; however each talc consuming industry has its own quality requirement in term of chemical composition and other physical properties. For example talc to be used in cosmetic industry should be of higher grade, pure white color, low in lime and iron content, with good slip and free from gritty and hard minerals particles like quartz, magnesite and tremolite. Similarly for electrical insulators chemically pure talc is desired and in foundries crude talc is also acceptable. Whiteness is also important in house paint and pharmaceutical talc. Cheap and off- white talc can be used in rubber, insecticides, paper and asphalt compositions.

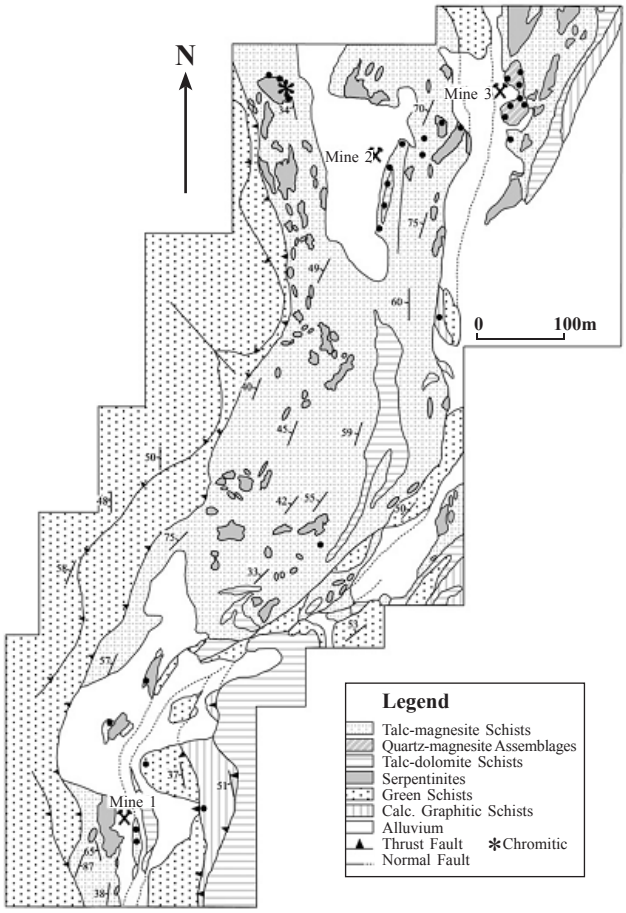

Figure 1: Geological Map of Mingora Emerald Mine Deposit Showing Talc Carbonates.

Talc processing is a costly operation and from economic point of view, it is done when specialized grade talc is desired otherwise the order of preference is to adopt hand sorting/cobbing, mechanical sorting, selective mining and using low grade talc for ordinary applications. However, with the passage of time the depletion of high grade talc and its increasing industrial demand invoke the need to conduct research for upgrading non-commercial resources of talc. In this context the present research study was undertaken.

Talc deposits occur in KP at different localities including Sherwan area of Hazara Division Kurram agency, Mohmand agency, and Swat area. Talc reserves in swat area of KPK have not been calculated precisely, however have been estimated in billions of tons with variable proportions of talc and carbonates content. Important deposits in Swat area are located in Mingora, Gujar Killi, Lilaunai, Alpurai, Shamuzai, Barkotkai and Shangla areas. Figure 1. shows geology of Mingora emerald mines deposits and talc carbonate rocks under study[1].

EXPERIMENTAL WORK

MATERIAL, METHODS AND EQUIPMENT USED

Excavated talc carbonate samples, weighing about 50Kg were collected from Mingora emerald mine, District Swat, KP with the help and cooperation of Directorate of Mines and Minerals, KP. The same sample was used through- out this research. The equipment used in the research is given in Table 1. Various processing techniques are in use worldwide for removal of the associated gangue minerals with talc like hand/optical sorting, differential grinding and sizing, magnetic separation, gravity separation, air separation, flotation and leaching. As talc is naturally floatable mineral like sulfur and molybdenum, flotation is a widely used technique by the researchers to extract talc from the talc bearing rocks. In the light of literature review[2-7] flotation and leaching processes were employed for separating talc from associated impurities of Mingora emerald mine ore. Both these processes are costly but justifiable because price of the fine grade talc so obtained by these processes is high in the international market ranging from $200 to $350 per ton (USGS website).

CHEMICAL COMPOSITION OF MINGORA TALC CARBONATE

X- Rays Fluorescence(XRF) spectrometer

Three representative samples of original rock were analyzed by XRF in Centre of Excellence in Geology University of Peshawar and two representative samples of original rock were analyzed by XRF in Pakistan Council of Scientific and Industrial Research (PCSIR) Laboratories Complex Peshawar. The analysis results were averaged together and presented in Table 2.

PROCESSING STUDY

Grinding of Talc Rock

Previous studies[8] reveal that when talc ore is ground, two types of surfaces are produced, One elongated or parallel to the flakes called faces and the other by breaking of bonds i.e across the flakes surfaces called edges Talc particle faces are hydrophobic and edges are hydrophilic, so grinding of talc ore for flotation should be arranged such that faces surface area produced by grinding is maximum as compared to edges surface area. In addition to this over grinding of ore should also be

Table 1: Equipment and Testing Facilities Used in The Research

S.No	Equipment	Purpose of use	Laboratory/Organization
1.	Jaw Crusher & Roll Crusher	Crushing Talc carbonate lump samples	Mineral Testing Laboratory, Hayatabad Peshawar
2.	Rod Mill, Model D.R , AMDEL Australia, Sr.No BRD – 104	Grinding of crushed ore to desired size	--------do--------
3.	Vacuum Filter Model B52208, Sr. NO 31441, UK.	Dewatering of grinding and flotation and leaching test products	--------do--------
4.	Sieve Shaker, Model ACTAGON 200, UK	Sizing of ground ore	--------do--------
5.	Denver Laboratory Flotation machine, Model D-12,Process Equipment Limited , England, UK	Flotation Tests	--------do--------
6.	pH Meter , Model HI 8424m, Singapore	For pH measurement in flotation	--------do--------
7.	Electric Oven , Model A-9VC, UK	Drying the wet sieving and flotation test products	--------do--------
8.	Datacolor, Model FX50X, USA	Whiteness measurement of Talc concentrate	PCSIR Laboratories Complex, Peshawar.
9.	XRF Spectrometer, Model S4 Pioneer 7kp1060, Bruker Company Germany	Chemical analysis of original ore, flotation and leaching products	PCSIR Laboratories Complex, Peshawar
10.	XRF Spectrometer, Regaku Japan	Chemical analysis of original ore, flotation and leaching products	Centre of Excellence in Geology, University of Peshawar, Peshawar
11.	Muffle Furnace, Model FP 41, Yamato, Japan	Chlorination of Talc	Department of mining Engineering, UET Peshawar
12.	Centrifuge (BHG HERMLE Z-230) Germany made	Improving whiteness of talc	Mineral Testing Laboratory, Hayatabad Peshawar
13	Sub Sieve Analysis Apparatus (Technica), England, UK	Sedimentation	Mineral Testing Laboratory, Hayatabad Peshawar
14	Assay Furnace, Carbolite, England UK.	Improving whiteness of talc	Mineral Testing Laboratory, Hayatabad Peshawar

Table 2: Chemical Composition of Mingora Talc Carbonate Rock

Sample No	Chemical Composition(%)											
	SiO_2	MgO	CaO	Cr_2O_3	Fe_2O_3	Al_2O_3	K_2O	Na_2O	NiO	PbO	MnO	LOI
1	36.01	41.21	0.42	0.50	4.89	0.31	0.24	0.38	0.170	LLD	0.01	18.5
2	32.20	37.85	1.68	0.47	4.82	0.30	0.54	0.73	0.264	0.003	0.13	23.93
3	26.50	38.57	0.45	0.16	5.04	0.40	0.07	0.95	0.245	0.002	0.15	28.06
4	29.65	35.54	1.56	0,78	4.29	2.80	0.13	0.89	0.680	0.006	0.16	20.30
5	32.20	32.94	0.99	0.30	5.538	0.52	0.08	0.25	0.028	0.004	0.15	27.44
Average	**31.31**	**37.222**	**1.02**	**0.442**	**4.92**	**0.866**	**0.21**	**0.64**	**0.278**	**0.004**	**0.12**	**23.65**

avoided to reduce edge formation and to reduce formation of fines. Fine particles of gangue produced due to over grinding are entrained in froth product reduce quality of concentrate. Further literature reveals that floatability of talc increases if the ore is ground by rod mill instead of ball mill[9]. The reason is, rod mill grinding produces particles with the highest flatness to elongation ratio as well as smoothed surface particles, both resulting into increased hydophobicity. Therefore original ore sample was wet ground in rod mill after crushing in Jaw crusher with ½ inch product size and roll crusher with 2 mm product size with following parameters:

Mill Size: Length 255mm, diameter 190mm, No. of steel rods= 15 of 15 mm diameter and 23 mm length each, Speed of the mill = 69 rpm, Ore water ratio: 60: 40

The recommended talc liberation size in the ore under study is -45μm as confirmed by flotation tests at different grind size. Flotation tests were conducted using 200g ground ore with varying grinding time of 15, 20, 25, 30, 35, 40, 45 and 60 minutes to confirm talc liberation size and optimize grinding time. Whiteness and Loss on Ignition (LOI) of flotation product were taken as criterian for product quality quantification. Loss on ignition correlate the amount of carbonates i.e high LOI content indicates higher amount of carbonates association with talc and vice versa.

Whiteness indicates association of metallic contents particularly irons bearing minerals. The Flotation parameters adopted in these tests were those of clean flotation presented in Table5. Flotation results of these tests are given in Table 3.

PROCESSES USED FOR TALC SEPARATION/ UPGRADATION

1. Ore Blending

Attempts were made if the grade of talc ore could be improved by blending talc of different indigenous deposits using solver computer program to avoid costly processing operation. The composition of the indigenous deposits talc is presented in Table 4[10-12]. The grade improvement is marginal due to small difference in the compositional factor of talc ores of different localities as shown in Table 4.

2. FLOTATION AND CHEMICAL LEACHING TESTS

I. Flotation Tests

Bench scale flotation tests were conducted adopting simple flotation schematics/circuits shown in Figure 2 to find the easiest and economical processing route to obtain high quality talc product. The tests were conducted at optimum parameters presented in Table 5, selected from previous studies[2-7,13]. The first stage of flotation where depressant and collector was used is called rougher flotation. In this stage only frother was used to increase bulk recovery of talc with minor impurities. No collector and depressant was used in rougher flotation because part of collector may coat on magnesite particles and make them float as well. Kerosene oil was added with oleic acid in order to enhance selectivity between talc and carbonate flotation. In clean flotation test pH of the pulp was first adjusted and then the reagents were added in the pulp.

In circuit1/schematic1, one step flotation test was conducted at optimum parameters of clean flotation to check the grade of talc concentrate, taking 400g of ore as feed. Weight of the concentrate was 180g and tail as 218g.

The purpose of schematic-2 was to see if two products i.e. low grade talc and high grade talc as concentrate 1 and 2 respectively could be obtained. The starting weight for this schematic was 400g, weight of the concentrate 1 was 230 g and tail1 as 168.20g with loss of 1.8g. Concentrate1 was then taken as feed in clean/2nd step flotation of the circuit. Weight of concentrate 2 was 220g and tail 2 as 9.80g. Products of flotation of circuit 2 i.e concentrate and tail are shown in Figure 3.

In schematic-3 weight of feed was 500g. Weight of concentrate 1 was 188.50g, concentrate2 as 246.32 g, tail2 as 61.5g. The purpose of floating talc from tailing 1 product in circuit 3 was, if some useful magnesite product could be obtained, as tailings 2, but on comparing it with standard grade magnesite, difference in composition was too much. The standard grade magnesite composition is SiO_2 1-2 %, MgO 43-44%, Fe_2O_3 0.5-1.5%, CaO 1.5- 2.5 % and LOI as 50-51%.

One flotation test with two step flotation was conducted using sodium silicate as dispersant (0.4g/400g). Weight of concentrate 1 in this test was 220 g, concentrate 2 as 156.0 g, tail1 as 178.0g and tail 2 as 49.50g. Concentrate 1 was used as feed in second step flotation. No appreciable change in recovery and grade/whiteness of concentrate was observed by the use of dispersant.

II. Chemical Leaching Tests

Leaching is the recommended technique for further purification of talc after flotation as flotation process

Table 3: Whiteness and LOI of Flotation Tests Products of Varying Feed Size/Grinding Time

Grinding Time (Minutes)	Weight of concentrate(gms)	Whiteness	Loss on Ignition
15	131.10	52.5	13.60
20	110.30	53.0	13.25
25	145.00	54.4	12.80
30	126.60	57.5	12.44
35	144.50	60.5	11.27
40	135.29	62.0	8.89
45	148.50	66.0	8.68
60	150.00	68.0	6.47

Table 4: Composition of Talc of Different Localities in Pakistan

Content (%)	SiO_2	MgO	Fe_2O_3	Al_2O_3	CaO	LOI	Na_2O	K_2O	Pb	Mn
Parachinar	64.76	31.84	0.27	0.65	0.48	1.56	-	-	-	-
Mingora emerald mine (Swat)	31.31	37.22	4.92	0.87	1.02	23.65	0.64	0.25	0.005	0.12
Sherwan(Hazara)	52.89	23.51	4.42	4.89	4.67	5	2.38	0.22	-	0.05
Kot (Malakand)	46.12	24.78	6.62	2.81	13.67	4.06	0.52	0.02	-	0.08
Prangghar (Mohmand agency)	48.78	25.62	5.05	2.78	8.87	5.89	0.47	0.01	-	0.02
Jamrud	58.85	31.72	0.43	0.41	0.22	7.48	-	-	-	-

alone cannot improve the composition and whiteness of talc up to the desired limits[2-7, 13]. The concentrate 2 of better composition obtained from two steps flotation in circuit 2 was subjected to acid leaching specifically for iron removal and improving whiteness.

In each leaching test about 20g concentrate was put in 250 ml leach solution. Weight loss after leaching and filtrate was 3 -4 g and weight of residue (talc) was 16 -17g. Different leaching agents were tested such as solution of (HCl (10% -30%) in water + stannous chloride Sncl2 (300ppm)) , Oxalic acid (0.2 M solution (1.26g/ Kg), Sulfuric Acid and Ethylene diamine tetra acetic acid (EDTA) . Effect of combination of acids like HCl + H2SO4 , HCl +HNO3 and H2SO4 + HNO3 were also tested. Temperature was kept as 60 to 70° C and leaching time as 1 hr.

Dilute HCl (30%) +$SnCl_2$ (300ppm) gave better result followed by Oxalic acid and EDTA. Sulfuric acid alone gave poor result. HCl concentration was varied from 10 to 30% in water. Whiteness increased with acid strength and at 30% concentration in water along with $SnCl_2$, maximum improvement in whiteness and composition of

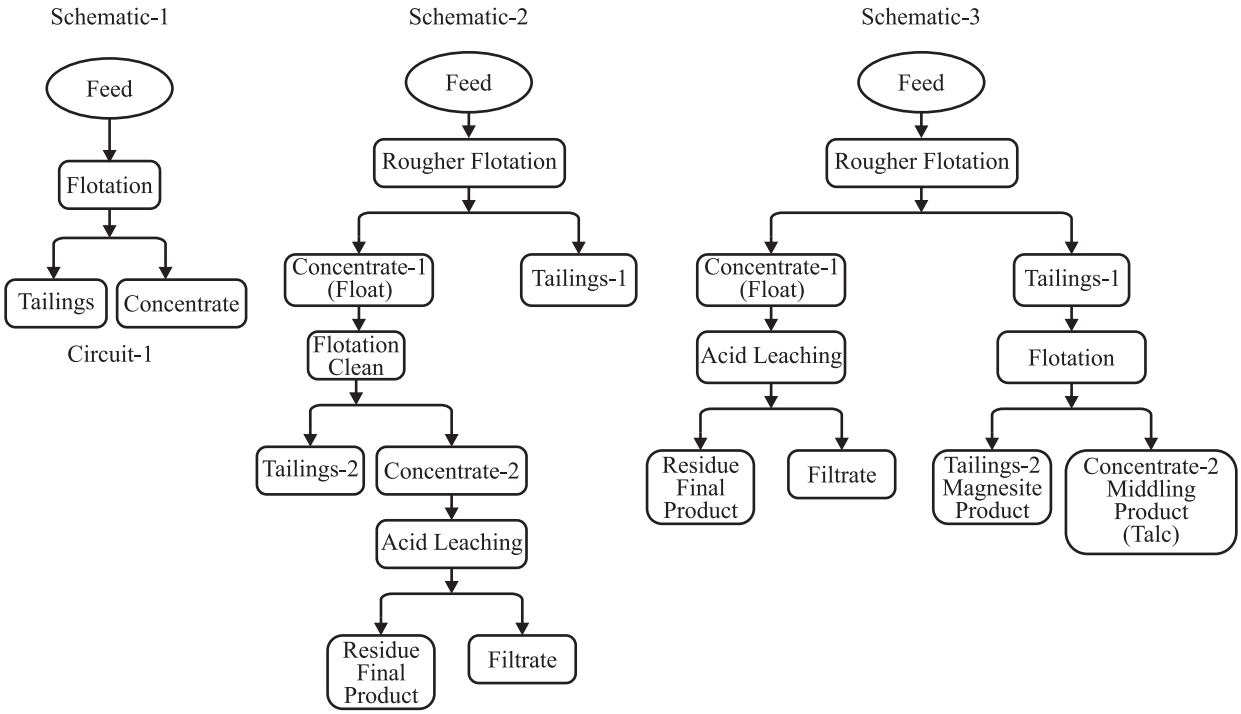

Figure 2: Flotation Schematics

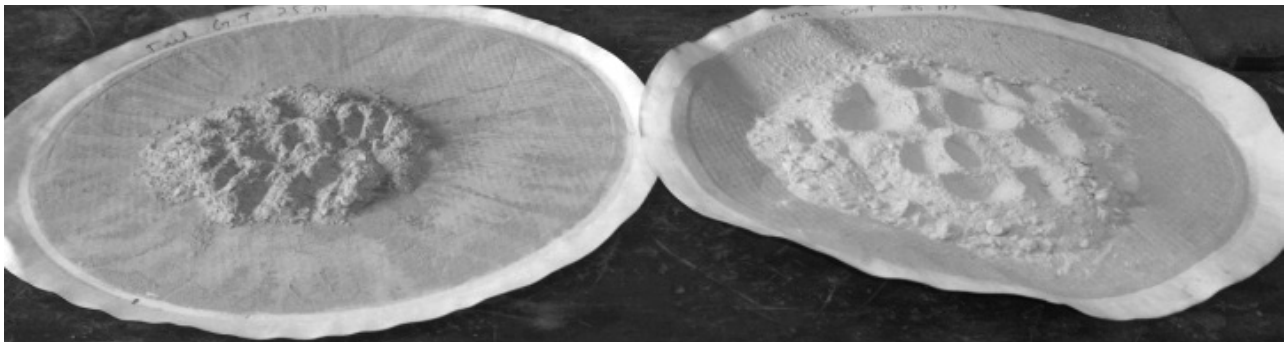

Figure 3: Products of Flotation, Concentrate (Right) and Tail (Left)

Table 5: Flotation Test Parameters

Process	Parameter	Reagent Dosage/Value
Rougher Flotation	Feed particle size	-45 microns
	Pulp density	25%
	pH value of the pulp	6 - 7±0.2
	Depressant	Nil
	Collector	Nil
	Froth collection time	5 minutes
Clean Flotation	Feed particle size	-45 microns
	Pulp density	20%
	pH value of the pulp	10.5- 11±0.2
	Depressant	Sodium hexameta phosphate 1kg/ton
	Collector	(Oleic acid + kerosene oil) 1.2k/ton
	Conditioning time for depress, & collector	5 minutes each
	Froth collection time	5 minutes
	pH regulator	Sodium hydro oxide(NaOH)

final product was achieved. $SnCl_2$ react with iron oxide in talc and convert it into ferrous chloride which is more soluble in HCl and thus improves leaching efficiency of the acid. The comparison of standard, original talcose rock of Mingora mine, Flotation final concentrate and leached concentrate of this research are presented in Table 6 and 7. In this table difference in SiO_2 content is taken as 0 because free silica present as impurity is 0. The results of flotation and leaching tests are graphically presented in Figure 5. In pure talc ratio of SiO_2 and MgO is about 2:1, So level of. SiO_2 and MgO was calculated on this basis in flotation and leached products. The discs of leached talc product made for chemical analysis are shown in Figure 4.4.

3. TESTS FOR IMPROVING WHITENESS OF TALC.

1. Increasing Grinding Time of Flotation Feed Sample

The original sample was grind for 75 minutes instead of 60 minutes (optimum grinding time) and subjected to two stage flotation circuit keeping other optimum parameters fixed. No improvement in whiteness of the concentrate was seen.

2. Centrifuging

For improving whiteness final leached concentrate was put into 2 test tubes and centrifuged with 2000 r.p.m for 5 minutes. The separated layers could not be easily separated because the material sticked to walls and bottom of test tubes. The layers were to some extent separated by wash bottle but the improvement in color was negligible.

3. Sedimentation in Sub-Sieve Analysis Apparatus

30 gm final leached concentrate sample was taken in a sub-sieve analysis tube. To keep the particle in

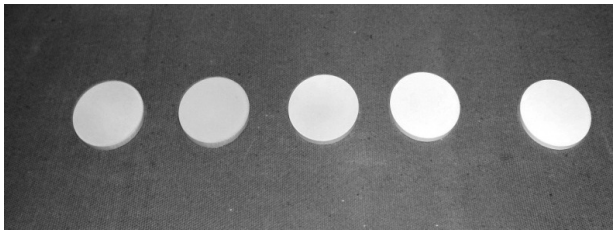

Figure 4: Discs of leached Talc product.

Table 6: Flotation and Leaching Tests Results

Process	Product	SiO_2	MgO	CaO	Cr_2O_3	Fe_2O_3	Al_2O_3	Na_2O	NiO	PbO	MnO	LOI
schematic1	Concentrate 1	46.46	31.50	3.62	0.29	1.32	1.17	1.23	0.38	0.02	0.16	14
Schematic2	Concentrate 1	58.28	29.30	0.014	0.22	4.77	N.A	N.A	0.48	N.A	0.04	6.47
	Concentrate 2	56.97	30.60	0.35	0.25	4.37	0.14	N.A	0.44	N.A	0.03	6.34
	Leached product of Concentrate 2	61.99	29.02	N.A	0.20	2.89	N.A	N.A	0.48	N.A	N.A	4.93
Schematic3	Concentrate 1	58.28	29.30	0.014	0.22	4.37	N.A	N.A	0.48	N.A	0.04	6.47
	Leached product of Concentrate 1	60.29	29.44	0.07	0.14	4.27	N.A	N.A	0.42	N.A	N.A	5.30
	Tailing 2	37.02	31.43	1.18	1.09	12.31	1.09		0.51	0.01	0.10	14.04
	Leach filtrate	00	traces	traces	-	9.98	3.72mg/l	280mg/l	-	-	0.42	-
	Head sample	31.31	37.22	1.02	0.442	4.92	0.866	0.64	0.28	0.004	0.12	23.65

Table 7: Comparison of Original Rock, Flotation and Final Leached Products With Standard

Product	Whiteness	SiO_2	MgO	CaO	Cr_2O_3	Fe_2O_3	Al_2O_3	Na_2O	NiO	PbO	MnO	LOI
Original Rock	51	31.312	37.222	1.02	0.442	4.92	0.87	0.64	0.278	0.004	0.12	23.17
Standard	95	62	31	0.25	0	0.5	0.25	0.4	0.004	0.001	0. 005	5.0
Difference	44	0	21.567	0.77	0.442	4.42	0.62	0.11	0.274	0.003	0.115	18.17
Concentrate-2	58	56.97	30.6	0.35	0.25	4.77	0.14	N.A	0.44	N.A	0.03	6.34
Standard	95	62	31	0.25	0	0.5	0.25	0.4	0.004	0.001	0. 005	5.0
Difference	37	0	2.16	0.1	0.25	4.27	0	0	0.436	0	0.025	1.34
Leach product	80	61.99	29.02	N.A	0.20	2.89	N.A	N.A	0.48	N.A	N.A	4.93
Standard	95	62	31	0.25	0	0.5	0.25	0.4	0.004	0.001	0. 005	5.0
Difference	15	0	0	0.22	0.17	2.01	0.08	0	0.396	0	0	0.00

suspension about 2g/100g of sodium hexa metaphosphate was added to the solution to depress the gangue. The solution was then shacked well and kept stationary for 10 minutes so that heavier particles can settle down and lighter particles remains above in suspension. The upper layer was sucked and collected in the beaker. The remaining again shacked and retained. This process was repeated 6 times, getting talc from suspension and impurities from the bottom. Both products were filtered and dried. Weight of residue was found as 2g and talc concentrate as 28 gm. The whiteness of talc was improved from 80 to 82%.

4. Sedimentation By Separating Funnel

30 g final leached concentrate sample was taken and mixed with water in a beaker. The pH of the solution was 7. To increase pH to about 11, sodium hydroxide was added to solution.0.2 g sodium hexa metaphosphate and 0.2 g sodium silicate was also added to solution to depress the gangue and to keep the particles in disperse state. The solution was then put in separating funnel, well shacked and retained for about 5 minutes. The stopper was just released for a while and the heavier particles layer was collected in a beaker. The two separated layers were filtered and dried. The whiteness of talc was improved upto about 80%.

5. Grinding of Concentrate

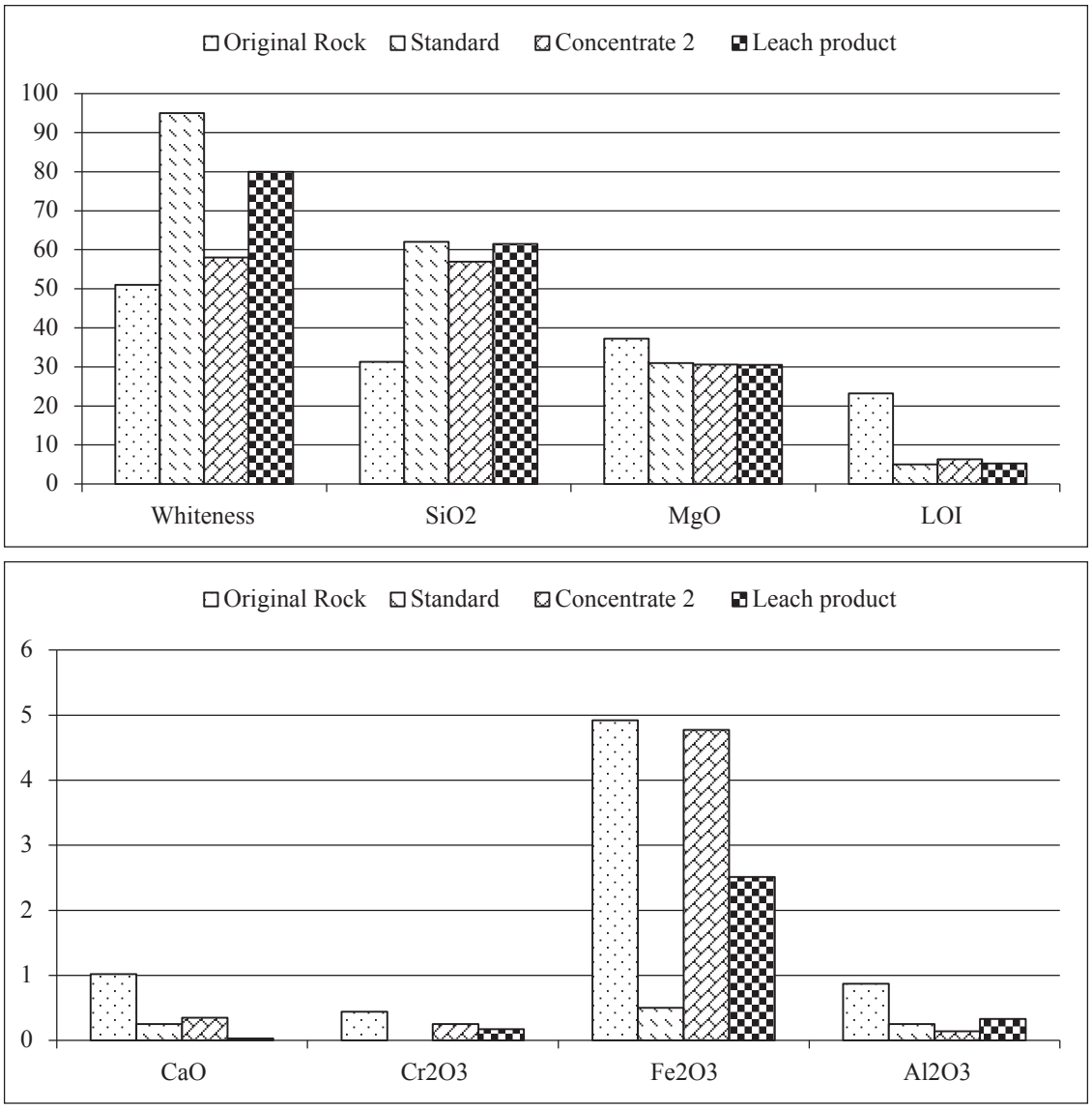

Figure 5: Graphical Presentation of Flotation and Leached Test Products Results of Table 7

The variations of the grain size and of the shape factor must induce a whiteness variation of talc. The original leached concentrate was grind in mortar mixer and the size was further reduced. The whiteness improved by about 2%.

6. By Calcination

The final leach product was heated upto 400 ^{0}C in assay furnace and then cooled. Instead of increase in whiteness it color turned brown. It indicate that Iron particles are present either in lattice of talc or have made coat on surface of talc grains. Brown color resulted due to oxidation of iron particles.

7. By Chlorination

The leached talc concentrate if heated in presence of Chlorine and nitrogen gas improve its whiteness[14]. Leached talc concentrate was mixed with a compound containing about 60% solid chlorine gas in ratio 1:1. This compound was obtained from industry at industrial estate Hayatabad Peshawar which is being used in the manufacture of Aquapura (water chlorination) tablets.

The mixture was heated in muffle furnace at 500° C for 1 hr. No improvement in whiteness was observed.

The final Flow sheet for extraction of talc from talc carbonate rock under study is given in Figure 6.

CONCLUSIONS

1. Mingora Emerald mine talc can be purified sufficiently by flotation however single step flotation does not yield concentrate of desired grade and at least two step flotation with optimum parameters is required. In three step flotation the weight of tail in third step was negligible therefore two step flotation is considered enough for the talc up gradation under study

2. The possibility to obtain magnesite as by product from talc flotation was explored but the grade of magnesite recovered as tail product is very low and its further processing is needed. Low grade magnesite so obtained can be utilized as an additive in wall plaster substances and other ordinary applications.

3. After leaching talc concentrate, the analysis result of filtrate in Table 6, shows MgO content in traces which indicate that almost all the magnesite has gone into tail product during flotation.

4. The leaching results of Hydrochloric acid, Oxalic acid, Sufuric Acid and EDTA reveals that hydrochloric acid results were better followed by Oxalic acid in term of iron removal and whiteness whereas Sulfuric acid and EDTA gave very poor results.

5. Removal of iron from flotation and leaching test products needs more research work. It seems that iron particles are present in the lattice of talc grains.

6. The final talc product obtained through this study can be used for ceramic, industrial paint, rubber, plastic and all other applications where desired whiteness is not above 82%. Some improvement in whiteness may be obtained if ceramic grinding media is used for grinding the head sample instead of using steel rods and also ceramic cylinder/vessel.

7. Effects of other flotation reagents used by researchers can be tested like soda ash and caustic soda as modifier, Primary amine and potassium xanthate as collector , Quebracho (derivative of tannin) and starch as depressant, pine oil and methyl isobutyl carbinol as depressant.

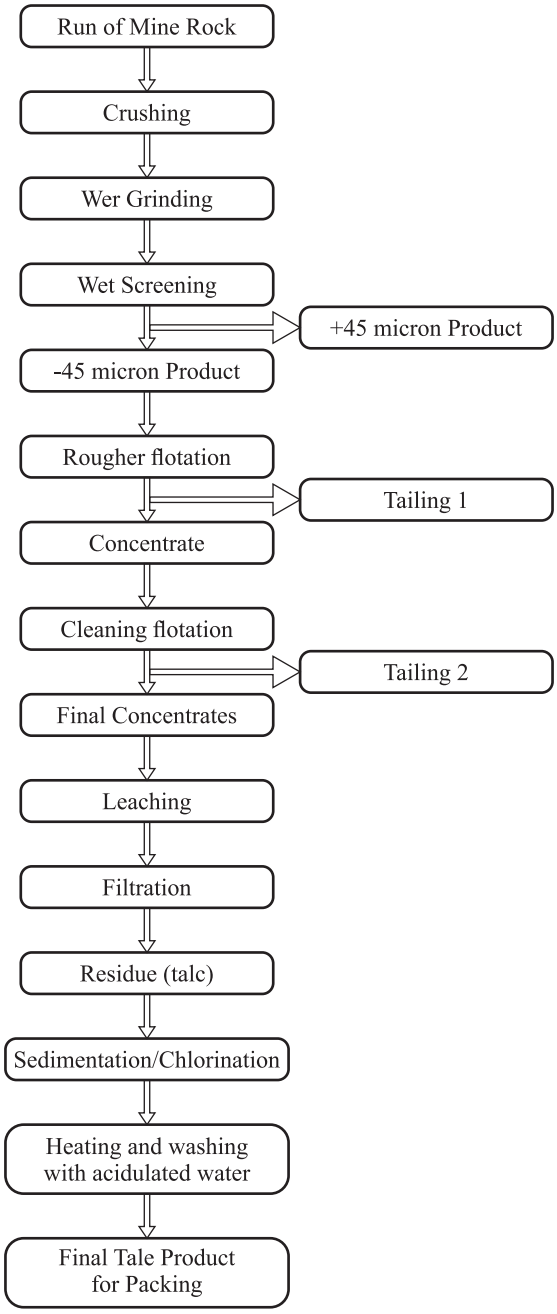

Figure 6: Proposed Flow Sheet For Extraction of Talc From Talc Carbonate Rock.

8. Improvement in the whiteness of leached talc product up to target i.e about 95 need detailed chlorination study using special apparatus with the use of chlorine and nitrogen gas.

REFERENCES:

1. *Arif M., Henry D.J, Moon C.J (2011) "Host rocks characteristics and sources of chromium and berllyium for emerald mineralization in the Ophiolitic rocks of the Indus Suture zone in Swat, NW Pakistan." Ore Geology Reviews 39 1-20, Elsevier Publishers.*

2. *Hussein S.A, M.I Alwakeel, and A.E Khazbak (1997)"Geochemistry and beneficiation of Egyptian Talc carbonate rocks" Third conference on Geochemistry, Alexandria Egypt September 3-4.*

3. *Adel Vatandoost, (2001) "How to Reach Pharmaceutical Grade Talc from Iranian Resources" CIM Minespace.*

4. *Mahmoud M.Ahmed, Galal A Ibrahim , Mohamed M.A. Hassan (2007) "Improvement of Egyptian Talc quality for industrial uses by flotation process and leaching" International Journal of Mineral processing 83 132-145.*

5. *Anderws, P. (1986) "Processing Talc in Canada. A Review of Studies at CANMET". Industrial Minerals. 63-69.*

6. *Sarquis P.E, Zalez M. (1998) "Technical note on limits of the use of Industrial talc - The carbonate effect" Minerals Engineering, Vol. No. 17, 657-660.*

7. *Jan Derco, Zoltan (2002) "Obtaining of High Quality talc from Talcose rock " A case study from the Sinec and Kokava Deposits, Slovakia" Boletin Paranaense de Geociencias No 50, 119-130.*

8. *Ugur Ulusoy, Meftuni Yekeler (2005) " Correlation of the surface roughness of some industrial minerals with their wettability parameters" Chemical Engineering and Processing 44 557-565.*

9. *Hicyilmaz C., Ulusoy U., Yekeler M. (2004) "Effects of shape properties of talc and quartz particles on the wettability based separation processes" Applied Surface Science 233 204-212.*

10. *Report on local talc by Mineral Development Corporation of Pakistan, Peshawar office.*

11. *Noor Jehan, (2004) Ph.D. thesis, National Centre of Excellence in Geology, University of Peshawar.*

12. *Razi Ahmad and Zakki Ahmad Siddique, (1993) "Minerals and Rocks for Industry, volume III, Geological Survey of Pakistan.*

13. *Hojamberdiev Mirabbos, Arifov Pulat , Tadjiev Kamil, Xu Yunhua, (2010) "Characterization and processing of talc-magnesite from the Zinelbulak deposit", Mining Science and Technology, Elsevier, 20 0415–0420*

14. *Orosco R.P, del M, Ruiz C, Barbosa L.I, González J.A (2011) "Purification of talcs by chlorination and leaching" International Journal of Mineral Processing, 116-120.*