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"BENEFICIATION OF POOR GRADE KYANITE FROM AMDA LAPSO MINES, BIHAR"

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ABSTRACT

A sample of poor grade kyanite from Amda Lapso kyanite mines was received from M/s. Indian Copper Corporation, Ghatsila, Bihar for beneficiation tests. The sample as received assayed 38.2% Al_2O_3, 50.6% SiO_2, 3.1% Fe_2O_3, 1.0% TiO_2, 2.4% CaO, 1.5% MgO, 1.15% (Na_2O + K_2O). Quartz and muscovite were the main gangue minerals with minor quantities of Sericite, Chlorite, Rutile etc.

Hydroclassification followed by Tabling at -48 mesh did not give satisfactory results. Flotation with a deslimed feed at 3.8 pH employing Lactic acid and sodium sulphonate followed by four cleanings yielded a final concentrate assaying 60.4% Al_2O_3 with a recovery of 48.8% Kyanite in it.

INTRODUCTION

At the instance of Messrs. Indian Copper Corporation, Ghatsila, the present investigation was carried out on their second (poor grade) sample of kyanite in National Metallurgical Laboratory, Jamshedpur. It may be pointed out that a better grade of kyanite assaying 54.9% Al_2O_3 was investigated earlier vide I.R. 430/67.

SAMPLE

About 150 Kgs. of poor grade kyanite sample from Amda Lapso kyanite mines was received from Messrs. Indian Copper Corporation, Ghatsila for beneficiation studies. The sample as received contained lumps from 10 to 1.5 cm in size and had practically no fines. A representative portion of the sample was stage-crushed to -10 mesh and used for experimental purposes. Chemical analysis of the sample and sieve analysis of -10 mesh crushed sample are recorded in Tables 1 and 2 respectively.

Note.

1. No responsibility is taken for the results except in so far as they apply to the sample investigated.
2. Laboratory soft water was used for all flotation tests.
3. As the chemical analysis took a very long time, some of the samples were analysed in the Autrometer by X-ray Fluorescence method.

Table 1 - Chemical Analysis.

Constituent.	Percent	
Al_2O_3	38.2	About 25% is due to Kyanite and the remainder to Micas present.
SiO_2	50.6	
Fe_2O_3	3.1	
TiO_2	1.0	
CaO	2.4	
MgO	1.5	
$Na_2O + K_2O$	1.15	
L.O.I.	2.30	

Table 2. Sieve Analysis of -10 mesh crushed sample.

Mesh	Percent
-10+14	15.5
-14+20	18.2
-20+28	13.3
-28+35	10.1
-35+48	8.0
-48+65	5.6
-65+100	5.4
-100+150	3.8
-150+200	2.0
-200	18.1
	100.0

According to Mr. M.S.Chopra, Petrologist, the sample consisted of schistose and massive type of kyanite. Quartz and Muscovite were the major gangue minerals with minor amounts of sericite, rutile, etc. Kyanite was present as coarse crystals as well as fine acicular crystals and it constituted about 40% by weight of the ore. Most of coarse crystals of kyanite were well liberated below 48 mesh. The detailed petrological report is given in the Appendix.

EXPERIMENTAL RESULTS

As the coarse kyanite grains are liberated at a size finer than 48 mesh, about 8 Kg of -10 mesh sample was ground to 65 mesh and hydroclassified into coarse, fine and slime fractions. The sand and fine fractions were separately treated on a Wilfley table. Results of this test are recorded in Table 3.

Table 3. Hydroclassification followed by Tabling at 65 mesh.

Product	Wt.%	Assay%	Dist.% Al_2O_3
Coarse			
Table concentrate	26.7	48.85	34.4
Table middling.	8.4	36.69	8.1
Table tailing	13.2	32.86	11.4
Fine			
Table concentrate	2.0	34.10	1.8
Table middling	3.4	30.45	2.7
Table tailing.	6.3	28.54	4.7
Slime.	40.0	34.91	36.9
Head(calc)	100.0	37.94	100.0

The above results showed that Tabling at 65 mesh could not yield satisfactory results. The fine inclusions of kyanite in quartz grains and vice versa and the flaky nature of mica were responsible for inefficient separation of kyanite from gangue. As Al_2O_3 present in the ore is contributed by kyanite and micas, the actual recovery of Al_2O_3 due to kyanite would be higher than that given above on the basis of chemical assays.

FLOTATION

As tabling did not yield good results, flotation tests were next performed with the sample.

A few preliminary flotation tests were conducted to determine the optimum grind. Sodium sulphonate was used as collector for kyanite and lactic acid as depressant for mica. The flotation tests were done at low pH to depress quartz. H_2SO_4 was used as pH regulator.

1000 gms of -10 mesh sample were ground in a rod mill with 500 cc water for 10,13,16 and 19 minutes. The ground samples were deslimed and floated separately in a 600 gm. Fagergren flotation cell under identical conditions. pH during the tests was maintained at 3.8. The conditions of flotation are shown in Table 4.

Table 4. Flotation conditions:

% solids during conditioning = 37
% solids during flotation = 28

Reagent	Qty. in Kg/ton.	Time of condition-ing in min.	Time of flota-tion in min.	Products.
H_2SO_4	0.5	3	-	-
Lactic acid.	0.5	4	-	-
Sodium sul-phonate.	0.25	2	2	Float 1
-do-	0.25	2	1 1/2	,, 2
-do-	0.12	1	1	,, 3

The three floats were mixed and refloated thrice using no reagent. Results of these tests are given in Table 5.

Table 5. Results of Grind variation.

Test No.	%-200 mesh.	Product.	Wt.%	Assay% Al_2O_3	Dist.% Al_2O_3
1.	50.3	Refloat concentrate	30.6	55.2	43.6
		Refloat Tail III	3.6	49.9	4.6
		Refloat Tail II	3.7	38.0	3.6
		Refloat Tail I	9.5	34.2	8.4
		Primary Tail.	28.6	24.4	18.0
		Slime	24.0	34.9	21.8
		Head(Cal)	100.0	38.74	100.0
2.	56.0	Refloat conc.	33.7	55.8	48.0
		Refloat Tail III	2.2	35.5	2.0
		Refloat Tail II	3.0	33.4	2.6
		Refloat Tail I	13.0	32.0	10.6
		Primary Tail	19.4	22.8	11.3
		Slime	28.7	34.9	25.5
		Head(calc)	100.0	39.18	100.0
3.	61.9	Refloat conc.	31.8	54.0	44.3
		Refloat Tail III	3.0	38.5	3.0
		Refloat Tail II	7.6	33.4	6.5
		Refloat Tail I	15.3	29.8	11.8
		Primary Tail	10.0	17.7	4.6
		Slime	32.3	35.8	29.8
		Head(cal)	100.0	38.75	100.0
4.	67.0	Refloat conc.	28.9	54.3	41.1
		Refloat Tail III	2.2	38.4	2.2
		Refloat Tail II	4.6	35.8	4.3
		Refloat Tail I	13.8	32.3	11.7
		Primary Tail	18.0	21.5	10.1
		Slime	32.5	36.0	30.6
		Head(Calc)	100.0	38.22	100.0

The above results showed that a grind containing 56.0%-200 mesh was optimum for flotation and it had given the best result. Finer grinding was not found to improve the results.

pH variation:

A few flotation tests were next performed by varying the pH of the flotation pulp between 2.8 to 5 by adding 0.6 to 0.41 Kg/ton of H_2SO_4 and keeping other conditions same as in test 2. Results of these tests are given in Table 6.

Table 6. Results of pH variation

Test No.	pH	Product.	Wt.%	Assay% Al_2O_3	Dist.% Al_2O_3
5	2.8	Refloat conc.	34.2	54.8	48.2
		Refloat tails III	3.6	35.6	3.3
		Refloat Tails II	7.4	30.2	5.8
		Refloat Tails I	13.1	26.0	8.8
		Primary Tails	7.1	17.8	3.3
		Slime	34.6	34.4	30.6
		Head(calc)	100.0	38.83	100.0
6	3.8	Refloat conc.	33.7	55.8	48.0
		Refloat Tail III	2.2	35.5	2.0
		Refloat Tail II	3.0	33.4	2.6
		Refloat Tail I	13.0	32.0	10.6
		Primary Tails	19.4	22.8	11.3
		Slime	28.7	34.9	25.5
		Head(calc)	100.0	38.75	100.0
7	5	Refloat conc	37.5	52.8	48.9
		Refloat Tail III	2.7	31.8	2.2
		Refloat Tail II	7.1	30.6	5.6
		Refloat Tail I	12.0	26.8	8.3
		Primary Tails	10.6	20.0	4.9
		Slime	30.1	34.8	30.1
		Head(calc)	100.0	38.9	100.0

The results of the above tests showed that flotation at 3.8 pH followed by three cleanings yielded the best concentrate assaying 55.8% Al_2O_3 with a recovery of 48% Al_2O_3 in it. So 3.8 was taken as the optimum pH for flotation. But the required grade of 60% Al_2O_3 could not be obtained in these series of tests due to the presence of some free biotite grains and some grains of rutile and tourmaline in the refloat concentrate.

With a view to further improving the grade of concentrate the test No.6 was repeated under same conditions but the rougher concentrate was refloated five times. No reagent was added during reflotation. Results of this test are shown in Table 7.

Table 7. Reflotation test.

Test No.	Product.	Wt.%	Assay% Al_2O_3	Dist.% Al_2O_3
8	Refloat concentrate	30.0	58.4	45.0
	Refloat Tail V	1.0	45.2	1.2
	Refloat Tail IV	1.3	42.0	1.4
	Refloat Tail III	1.4	34.0	1.2
	Refloat Tail II	3.3	33.2	2.8
	Refloat Tail I	11.9	32.0	9.8
	Primary Tail	18.0	19.2	8.9
	Slime	33.1	35.0	29.7
	Head(calc)	100.0	38.93	100.0

The above results showed that even five cleanings without any reagent, of the rougher concentrate could not yield a concentrate of the required grade. So the same test(in Table 7) was repeated and the same number of reflotations were done using 0.12 Kg/ton of lactic acid in each stage. The results are shown in table 8.

Table 8. Reflotation test using 0.12 Kg/ton of Lactic acid in each stage.

Test No.	Product	Wt.%	Assay% Al_2O_3	Dist.% Al_2O_3
9	Refloat concentrate	25.0	59.2	38.2
	Refloat Tail V	1.5	50.3	2.0
	Refloat Tail IV	1.8	48.8	2.3
	Refloat tail III	2.3	43.7	2.6
	Refloat Tail II	6.6	40.0	6.8
	Refloat tail I	11.0	32.0	9.1
	Primary tail	19.9	20.0	10.3
	Slime	31.9	34.8	28.7
	Head(calc)	100.0	38.7	100.0

Five cleanings of the rougher concentrate using 0.12 Kg/ton of lactic acid in each stage of cleaning did not still yield the required grade of concentrate.

So in the following two tests (Test Nos. 10 & 11), a larger amount of slime was rejected before flotation which was performed exactly as in tests No. 8 and 9 respectively. The results are shown in tables 9 and 10 respectively.

Table 9. Reflotation without any reagent.

Test No	Product.	Wt.%		Assay% Al_2O_3		Dist.% Al_2O_3		Dist. of kyanite.
10	Refloat concentrate	17.0	20.2	61.1	60.4	27.2	32.0	48.8
	Refloat Tail V	3.2		56.82		4.8		
	Refloat Tail IV	2.0		51.9		2.7		
	Refloat Tail III	2.1		42.8		2.4		
	Refloat Tail II	3.3		41.6		3.6		
	Refloat Tail I	3.4		37.2		3.3		
	Primary tail	26.8		24.7		17.3		
	Slime	42.2		35.0		38.7		
	Head(calc)	100.0		38.20		100.0		

Table 10. Reflotation with 0.12 Kg/ton of Lactic Acid in each stage of cleaning.

Test No.	Product.	Wt.%	Assay% Al_2O_3	Dist.% Al_2O_3
11	Refloat concentrate	11.7	60.27	18.3
	Refloat Tail V	5.2	58.96	8.3
	Refloat Tail IV	4.1	56.8	6.1
	Refloat Tail III	2.5	54.2	3.5
	Refloat Tail II	2.5	51.0	3.3
	Refloat Tail I	3.5	37.4	3.4
	Primary tail	28.0	25.8	18.8
	Slime	42.5	35.0	38.3
	Head(calc)	100.0	38.48	100.0

The above results indicated that 5 reflotations of the rougher concentrate without any further reagent addition but after rejecting 42.2% by weight as slime yielded a concentrate assaying 61.1% Al_2O_3 with a recovery of 27.2% Al_2O_3, whereas 4 reflotations yielded a concentrate assaying 60.4% Al_2O_3 with a recovery of 32.0% Al_2O_3 present in the ore.

Microscopic examination on the combined concentrate showed that the sample consisted mostly of free kyanite with few grains of rutile and tourmaline. The original sample contained about 40% kyanite according to Petrological Report given in Appendix , and the final concentrate weighing 20.2% w.r.t. original, assayed 60.4% Al_2O_3. It may be noted that the original sample assayed 38.2% total alumina of which 25% is due to kyanite and the remaining 13.2% due to micas present. Assuming that the Al_2O_3 present in the final concentrate assaying 60.4% Al_2O_3 is all due to kyanite, the recovery of kyanite in this product would then be $\frac{20.2 \times 60.4}{25} = 48.8\%$.

A few flotation tests using other reagent combination like (i) oleic acid emulsion; and Aeropromoter 825; (ii) Katha and oleic acid emulsion; (iii) NaOH, sodium silicate and oleic acid emulsion were performed to see their effect on flotation of kyanite, but none of them could produce satisfactory results.

SUMMARY AND CONCLUSIONS

A poor grade sample of kyanite received from Indian Copper Corporation, Ghatsila for beneficiation tests assayed 38.2% Al_2O_3, 50.6% SiO_2, 3.1% Fe_2O_3, 1.0% TiO_2, 2.4% CaO, 1.5% MgO and 1.15% $Na_2O + K_2O$. Kyanite was present as coarse crystals as well as fine acicular crystals. Quartz and Muscovite were the main gangue minerals. Coarse crystals of kyanite were well liberated below 48 mesh.

The kyanite content in the sample according to the Petrologist is 40%. It is estimated that out of the total Al_2O_3 content of 38.2% in the ore, 25% of Al_2O_3 is contributed by kyanite and the rest by muscovite, sericite, chlorite, etc.

Hydroclassification followed by tabling of coarse and fine fractions did not produce satisfactory results.

Flotation of a deslimed feed after grinding to 56% -200 mesh and employing 0.5 Kg/ton of lactic acid as mica depressant, 0.5 Kg/ton of H_2SO_4 as quartz depressant, and 0.62 Kg/ton of sodium sulphonate as collector at pH 3.8 yielded a final cleaner concentrate after five cleanings assaying 61.1% Al_2O_3 with a recovery of 27.2% Al_2O_3. This concentrate when mixed with the fifth refloat tails would produce a combined concentrate assaying 60.50% Al_2O_3, 37.76% SiO_2 and 0.80% Fe_2O_3 with a recovery of 32.0% Al_2O_3 with respect to the total alumina in the ore equivalent to a recovery of 48.8% kyanite.

Flotation using other reagent combinations such as oleic acid emulsion and Aeropromoter 825; Katha and oleic acid emulsion, etc. did not give any satisfactory results.

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APPENDIX

Petrological Report on low grade kyanite from Amda Lapso Mine of Indian Copper Corporation.

By M.S.Chopra

Megascopic:

The kyanite bearing rock varied from light greenish grey to dark grey in colour. Some samples showed dirty white colour. The rock was predominantly schistose although massive type was also present. Quartz and muscovite could be distinguished by naked eye besides the kyanite.

Microscopic:

The rock was hypidiomorphic granular with a predominantly schistose texture. Kyanite was present as coarse crystals as well as fine acicular crystals. The latter were usually present as oriented inclusions in quartz. Some of the coarse kyanite crystals also had fine inclusions of chlorite and quartz, the former being probably alteration product of kyanite.

The gangue was primarily quartz and muscovite. Sericite, chlorite, rutile tourmaline, amphiboles and biotite were present in minor amounts.

Examination of sieve fractions of representative -10 mesh material showed that most of the coarse kyanite was liberated below 48 mesh. Fine inclusions of kyanite in quartz or vice versa were not liberated even in the -150+200 mesh fraction. Kyanite content was higher in the coarser fractions compared to the finer fractions. Average kyanite content of the ore was around 30% by volume or nearly 40% by weight, out of which coarse kyanite constituted about 75%.
