Diagnostic Process Characterization of a Banded Magnetite Quartzite (BMQ)

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Abstract:
A low grade Banded magnetite quartzite BMQ from Obalapuram, D.Hiremandal, Ananthapur district,Andhra Pradesh, India was subjected to Diagnostic process characterization amenability study The scope of the procure evaluation study comprises of characterization, diagnostic process amenability gravity. and magnetic process concentration tests verging mesh of grand. The sample assayed 36.31 % Fe{t},42.72% SiO_2, 5.12% FeO, 0,40% Al_2O_3, 1.14% MgO, 0,58% CaO, 0,31% alkalis, 0.13% TiO_2 , 0.1%P, 0.05% S and 1.16% LOI. The sample contained mainly very fine grained hematite, magnetite associated intimately with fine grained quartz. Amphibole, goethite, apatite and pyrite were found in minor to trace amounts. The process diagnostic amenability tests to size, specific gravity and magnetic separation indicate that the sample is amenability to gravity separation at very fine size of -0.07mm . The sample is also amenable to magnetic separation at very fine size of -0.07mm yielding washery grade.. A combination of gravity and magnetic separation yields concentrates meeting the BF grade requirements at size finer than 0.07mm. The sample is amenable to beneficiation at very fine sizes producing either BF pellet grade concentrates or coal washery media grade concentrates.

Key words: magnetite, magnetic separation, amenability, gravity separation

I. Introduction

The depletion of high grade iron ores and the increased demand for raw material by the iron and steel industry in the recent decade have imposed an urgent and challenging task to exploit lean iron ores like BMQ. (3). However, there are many difficulties in utilizing such iron ores with conventional separation techniques, because of its leanness in valuable components very fine interlocking of iron oxide minerals with deleterious gangue minerals like fine grained quartz, apatite and iron sulphides. The conventional flowsheet is effective in processing high or relatively high grade hematite ores cannot be economically applied to treat a lean grade iron ore like BMQ, due to the fact that it produces low concentrate yield, excessively high energy consumption requirement for the sufficient liberation of iron minerals in the comminution process (2). Just recently, a High Pressure Roll Grinding-HGMS method has been reported to be effective in the processing of a lean BMQe (2); and then is processed with HGMS of coarse rod matrix to discard gangues from the ore. In the present paper, an attempt has been made to study the amenability of the lean grade BMQ / BHQ from Obalapuram, D.Hiremandal, Anantapur district, Andhra Pradesh of Belagal range, Sandur Schist belt as little work have been carried out on BIO from Obalapuram, though quite significant work has been done on BMQ from adjoining Karntataka state (4-13).The specifications for iron ores for metallurgical and non-metallurgical uses are given in Table 1 and 2 respectively.

Table 1: Specification for iron ore for Iron & Steel Manufacture

Sl.No.	Constituent	Blast furnace	Steel making	Sinter feed	Pellet feed
1	Fe[T]%	>60	>62	>60	>64
2	SiO_2%	<4	<3	<4	<3
3	Al_2O_3%	<3	<3	<3	<3
4	SiO_2+ Al_2O_3%	<7	<6	<7	<6
5	P%*	<0.1	<0.1	<0.1	<0.1
6	S%*	<0.1	<0.1	<0.1	<0.1
7	Mn%	<2	<1	<2	<1
8	TiO_2%	<1	<0.5	<1	<0.5
9	Size mm	-30+10	-80+10	-10+0.1	-0.1
10	Tumbler index	>80	>80	-	-

*% P and S currently desired is < 0.05

Table 2: Specifications for iron ore for non metallurgical applications

Sl.No.	Constituent	Weighting agent/ filler	Coating	Welding	Ferrite/ Ferro fluids	Coal washer Media	Cement
1	Fe[T]%	>65	>63	>65	>69	>67	>45
2	SiO_2%	<2	<2	<2	<0.5	<2	<15
3	Al_2O_3%	<2	<2	<2	<0.2	<1	>10
4	LOI	<1	<1	<1	<0.2	<1	<15
5	Sp. Gr.	>4.8	>4.5	>4.5	>4.8	>4.8	-
6	Procter Density lb/ft^3	>200	-	-	-	-	-
7	Size mm	-5 +0.05	-0.05	-0.05	<0.05	<0.05	-5
8	Type	Hard hematite/ magnetite	Lamellar >70%	Lamellar >70%	Blue dust Magnetite	Hard Magnetite	Clayey iron ore

2 EXPERIMENTAL

2.1 Materials

The lean grade BMQ sample from M/s Sai Balaji Mines, Obulapuram, Ananthpur district, Andhra Pradesh was received for diagnostic process characterization studies. The samples were collected from all along the strike length, faces and different ore dumps to get a representative sample. The samples were collected from 2x2x2 m pits along with strike length of reef with 200 m interval, mined ore dumps and from mine faces. The lumps greater than 800 mm was crushed by sledge hammers to 100 mm size. About 4-5 tons of bulk sample including bored /drilled powder were collected in bags and containers for investigation from each study area.The standard feed preparation and sampling techniques were adopted and sub samples were drawn after homogenization followed by coning and quartering method. The sub samples drawn were subjected to physical, chemical and mineralogical characterization

2.2 Method

The collected samples were subjected to standard feed preparation and sampling method. The original sample was subjected to detailed Chemical analysis and mineralogical studies. Diagnostic Process Amenability studies varying MOG using heavy liequieds like TBE, hand bi pole bar magnet and Davis tube.

3 RESULTS AND DISCUSSION

The experimental results comprises of characterization of feed samples furnishing the physical, chemical, mineralogical data followed by amenability of sample to gravity and magnetic concentration.

3.1 Characterization studies

The characterisation studies comprises of physical, chemical and mineralogical studies.

3.1.1 Physical characterisation:

The as collected sample consisted of browhish to black grey coloured hard and compact lumps of -100mm size with little fines. The sample used to get attracted to hand magnet. It was bone dry and free flowing nature. The density and bulk density was found to be 3.18 and 1.94 t/m^3. The angle of repose was 38.7 degrees. Some lumps exhibited alternating bands.

3.1.2 Chemical analysis:

The sample assayed 36.31 % Fe{t},42.72% SiO_2, 5.12% FeO, 0,40% Al_2O_3, 1.14% MgO, 0,58% CaO, 0,31% alkalis, 0.13% TiO_2 , 0.1%P, 0.05% S and 1.16% LOI. The assay indicated that the sample contains mainly silica and anhydrous iron oxides.

3.1.3 Mineralogical studies:

Stereomicroscope can yield detailed information on minerals present and their texture, grain size, grain shape and oxidation effects. Reflected light microscopy is used to examine those minerals that do not transmit light in thin section but rather reflect light to varying degrees when polished. Such minerals include metallic sulphides and oxides for polished lumps and polished epoxy resin mounted grains. The transparent minerals are identified by thin sections and powders with RI liquids using transmitted light. The mineralogical data is given in Table 3 and shown in Fig 1-4. The ore is very fine grained martitized BMQ warranting a very fine Mesh of Grind for liberation and separation. The X-Ray diffraction study was carried out for the OBM feed sample to confirm the different mineral phases present in the ore samples which are as shown in figure.5. From the figure.5 it is clear that, magnetite, hematite are the major ore minerals where as quartz is the major gangue mineral, with trace amount of iron oxides like goethite

Table 3: Mineralogy of samples collected from Obalapuram study area

Obulapuram OBA
Compact hard brownish dark grey lumps with little fines. some lumps showing alternate bands
The as received sample consists of hematite, martitized magnetite and quartz. Goethite, amphibole, mica, carbonates apatite and pyrite are observed in traces.
Magnetite and martitized magnetite [20-25%] is fine grained (0.01-0.18mm) occur as discrete and granular aggregates as pockets in silicates. It shows inclusions of silicates (0.03mm). Intergranular spaces are filled with silicates (Ref Fig 1-4]
Hematite [30-35%] is fine grained (0.01-0.2mm) occur as discrete and granular aggregates as pockets in silicates. It shows inclusions of silicates (0.02mm). Intergranular spaces are filled with silicates and traces of goethite, carbonates and mica(Ref Fig 1-4)
Quartz [35-40%] and amphibole [3-4%] are fine grained (0.01-.0.15 mm) occur as granular aggregates as pockets. They also occur as filler in intergranular spaces and fine inclusions in iron oxides. (Ref Fig 1-4]
Trace amounts of very fine grained apatite and pyrite occur as inclusions (0.01mm) in iron oxides and silicates.
Opaque minerals and transparent minerals are found to be fairly liberated at 150 mesh size. The ore is very fine grained Martitized BMQ.

Fig 1 to 4 Photomicrographs of BMQ sample form Obulapuram Area

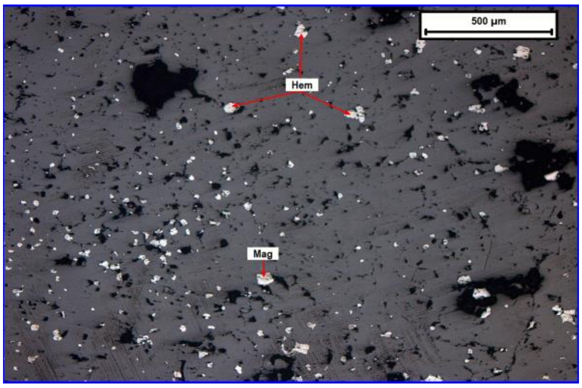

Fig. 7; Irregular shaped small Hematite(Hem) and Magnetite (Mag) grains. [X- 50].

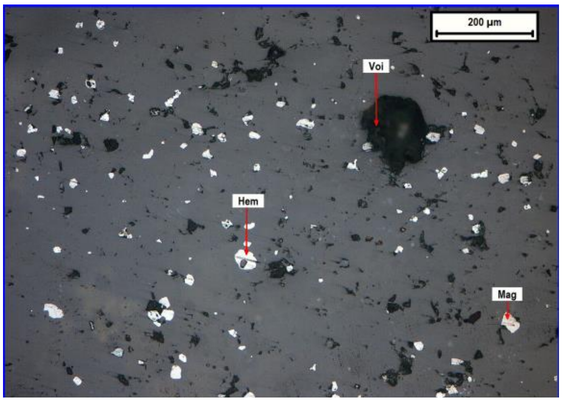

Fig.8;Small grains of Hematite(Hem) and few sub to anhedral Magnetite (Mag) grains. [X-100].

Fig 5: XRD of BMQ samples

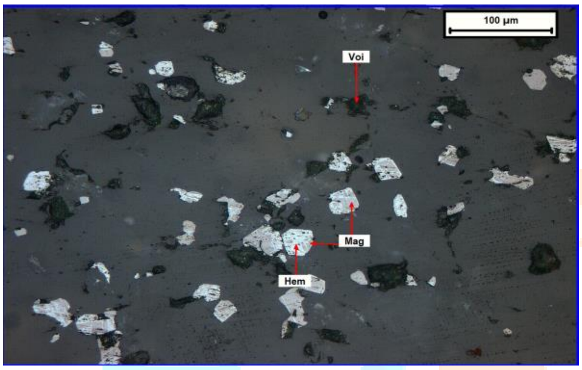

Fig.9; Association of medium size grain of Magnetite(Mag) and un altered Hematite(Hem)(X- 200).

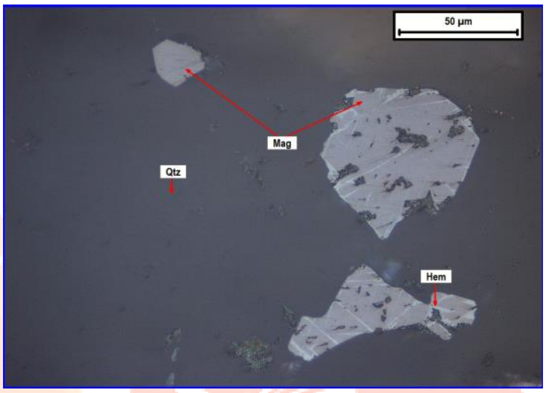

Fig. 10;Irregular shaped altering Magnetite(Mag) and un altered Hematite(Hem). (X- 100)

3.2 Effect of MOG on dry low intensity bar magnet separation amenability test

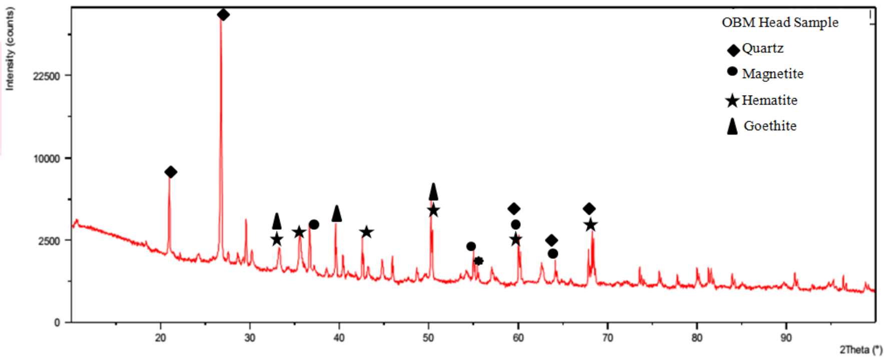

Fig 5: XRD of BMQ samples

3.2 Effect of MOG on dry low intensity bar magnet separation amenability test

The representative portion sample subjected to dry magnetic separator using hand rod magnet with by field intensity of 1000 gauss varying the field MOG from-30/-100/-200 mesh .The results are given in shown in table 4. The results indicates that the grade concentrate increases with fineness of size. The concentrate assaying 60.80 % Fe with 76.0% Fe distribution was obtained at -200 mesh grind .This may be attributed necessity to find grind of -150 mesh to liberate very finely inter ground fine grind magnetite with fine grind quartz.

table 4:amenability to DLIMS at varying MOG

MOG	Products	DLIMSAT Obulapuram		
		Wt.%	Fe% Assay	%Fe Distn
-50 #	Mag	53.0	51.62	76.0
	Nonmag	47.0	18.38	24.0
	Head Cal	100.0	36.00	100.0
-100#	Mag	48.0	55.50	74.0
	Nonmag	52.0	18.00	26.0

	Head Cal	100.0	36.00	100.0
-200#	Mag	45.0	60.80	76.0
	Nonmag	55.0	15.70	24.0
	Head Cal	100.0	36.00	100.0

3.3 Effect of MOG on dry low intensity bar magnet separation amenability test

The representative portion sample subjected to wet magnetic separator using hand rod magnet with by field intensity of 1000 gauss varying the field MOG from-30/-100/-200 mesh .The results are given in shown in table 5. The results indicates that the grade concentrate increases with fineness of size. The concentrate assaying 62.12 % Fe with 69.2% Fe distribution was obtained at -200 mesh grind just very close to pellet grade .This may be attributed necessity to find grind of -150 mesh to liberate very finely inter ground fine grind magnetite with fine grind quartz. The wet magnetic separation was relatively selective as compared to dry magnetic separation. . Results are similar to previous works of (IBM, 2015) (IBM, 2012) (IBM, 2011) (Sanjaykumar, 2017) (Purushotham, 2015) (KeerthiKumar, 2016) (Subbarao.A, 2017).

Table 5; Amenability to WLIMSAT varying MOG

MOG	Products	WLIMSAT Obulapuram		
		Wt.%	%Fe assay	%Fe Distn
-50 #	Mag	48.8	52.67	71.4
	Nonmag	51.2	20.11	28.6
	Head Cal	100.0	36.00	100.0
-100#	Mag	47.1	59.08	77.3
	Nonmag	52.9	15.45	22.7
	Head Cal	100.0	36.02	100.0
-200#	Mag	40.1	62.12	69.2
	Nonmag	59.9	18.51	30.8
	Head Cal	100.0	36.00	100.0

3.4 Effect of MOG on Davis tube wet low intensity amenability Test:

The ferro-magnetic mineral concentration employing Davis tube test was carried out varying the MOG from -60/-150/-270 mesh, the test was conducted .the conditions and the results of the Davis test. The result shown in Table 6.

Table 6. Effect of MOG on Davis tube Test.

MOG	Products	DTAT Obulapuram		
		Wt%	**Fe% assay**	**%Fe Distn**
-60 #	Mag	14	62.08	24.1
	Non mag	86	31.75	75.9
	Head Cal	**100**	**36.00**	**100**
-150#	Mag	28	66.21	51.5
	Non mag	72	24.25	48.5
	Head Cal	**100**	**36.00**	**100**
-270#	Mag	17	69.20	32.7
	Non mag	83	29.20	67.3
	Head Cal	**100**	**36.00**	**100**

Table 6 indicates that the grade and recovery of ferro magnetic concentration increases gradually and attains a maximum at -150mesh their after % Fe recovery falls with further increasing fineness of grin, though the grade increases further to 69.2%Fe.. The optimum results were obtained ar-150mesh, 2000gauss yielding concentrate assaying 66.21% Fe with 51.5 % Fe distribution at weight % yield 28, meeting the pellet grade requirements. However, supergrade concentrate meeting the coal washery specification may be obtained at very fine MOG of -0.05mm. The poor performance extreme sizes may be attributed to inter locking at coarse size resulting in tail loss and slimes generation and its interference

3.5 Diagnostic amenability tests involving Heavy liquid separation and dry hand magnetic separation of sinks varying MOG:

Representative samples (100 gm) of lean grade magnetite's of study area were subjected to Heavy liquid separation using Laboratory grade Bromoform of specific Gravity 2.9. The float and sink products were separately weighed and subjected to wet low intensity magnetic separation, varying the mesh of grind from 50, 100, 200 mesh. The results are given in Table 7. The above test indicates that the BMQ is amenable to gravity followed by WLIMS separation at sizes finer than 200 mesh. The data is supported by liberation data on the BMQ samples,.. The grade of concentrate increases with fineness of MOG and a MOG < 0.1mm is essential for separation either by gravity or magnetic separation.. Results are similar to previous works of (IBM, 2015) (IBM, 2012) (IBM, 2011) (Sanjaykumar, 2017) (Purushotham, 2015) (KeerthiKumar, 2016) (Subbarao.A, 2017) who had worked on BMQ from Karnataka and Andhra Pradesh.

Table 6: amenability to HLS and WLIMS of sinks

MOG	Products	Obulapuram		
		Wt%	Fe% assay	%Fe Distn
-50 #	Float	26.7	9.44	7.0
	Sink Mag	33.8	50.06	47.0
	Sink Non mag	38.5	43.30	46.0
	Head Cal	100.0	36.01	100.0
	Sink Cal	72.3	46.27	93.0
-100#	Float	36.4	11.81	10.0
	Sink Mag	41.2	52.43	60.0
	Sink Non mag	22.4	48.20	30.0
	Head Cal	100.0	36.00	100.0
	Sink Cal	63.6	50.93	90.0
-200#	Float	47.0	10.72	14.0
	Sink Mag	33.4	62.50	58.0
	Sink Non mag	19.6	51.50	28.0
	Head Cal	100.0	36.00	100.0
	Sink Cal	53.0	58.48	86.0

4 CONCLUSIONS

A low grade Banded magnetite quartzite BMQ from Obalapuram, D.Huremandal, Ananthapur district,Andhra Pradesh, India was subjected to Diagnostic process characterization amenability study The sample assayed 36.31 % Fe{t},42.72% SiO_2, 5.12% FeO, 0,40% Al_2O_3, 1.14% MgO, 0,58% CaO, 0,31% alkalis, 0.13% TiO_2 , 0.1%P, 0.05% S and 1.16% LOI. The sample contained mainly very fine grained hematite, magnetite associated intimately with fine grained quartz. Amphibole, goethite, apatite and pyrite were found in minor to trace amounts with a fair degree of liberation at -0.1mm. The process diagnostic amenability tests to size, specific gravity and magnetic separation indicate that the sample is amenable to gravity separation and magnetic separation at very fine size of -0.07mm yielding metallurgical grade concentrates with ~60% Fe distribution. Coal wahery media grade concentrates can be obtained by WLIMS at -0.07mm with about 30% Fe distribution.

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