

APPLICATION OF DRY HIGH-INTENSITY MAGNETIC SEPARATION IN UPGRADING LOW-GRADE IRON ORE OF ROUINA DEPOSIT –ALGERIA–

A. Messai^{1#}, A. Idres¹, J.M. Menendez-Aguado²

¹University of Badji Mokhtar, Faculty of Earth Sciences, Mining Department, Laboratory of Mineral Resources Valorization and Environment, Annaba, Algeria

²University of Oviedo, Polytechnic School of Mieres, Mineral Raw Materials Processing Research Group, Spain

(Received: April 8, 2020; Accepted: June 2, 2020)

Abstract

The recent developments of steel and iron industries generated a huge consumption of iron ores which has attracted much attention for utilizing low-grade iron resources to satisfy this increasing demand. The present study focuses on the characterization and enrichment of the low-grade iron ores from Rouina deposit -Ain Delfa-. Currently, the ore is used in the cement industry because it is considered a low-grade iron ore. After the sampling process, a physico-chemical and mineralogical characterization was carried out and the results revealed that the sample consists of hematite, limonite and goethite as major opaque oxide minerals whereas silicates as well as clays form the gangue minerals in the sample. The average grade of Fe_{Total} , SiO_2 and Al_2O_3 contents in the raw material collected from the mine of the case study are 30.85%, 23.12% and 7.77% respectively. Processes involving combination of classification, washing and dry high-intensity magnetic separation were carried out to upgrade the low-grade iron ore sample to make it suitable as a marketable product. The sample was first ground and each closed size sieve fractions were subjected to washing followed by drying than dry high intensity magnetic separation and it was observed that limited upgradation is possible. As a result, it was possible to obtain a magnetic concentrate of 54.09% with a recovery degree of 89.30% and yield of 62.82% using a magnetic field intensity equal to 2.4 Tesla at the size fraction $[-0.125 + 0.063 \text{ mm}]$.

Key words: Rouina; Iron ore; Sampling; Characterization; Washing; Magnetic separation.

1. Introduction

The deposits of high-grade iron ore are being exhausted increasingly because of their priority operations in a spirit of economic profitability where the essential part is mainly used in the steel industry [1]. This industry has significantly extended in recent years, and consumers demand of high-grade iron ores cannot be satisfied [2], faced with this challenge, the exploitation and processing of low-grade iron ores has become a necessity [3].

Mineral processing researchers have focused on the enrichment degree and the upgrading of iron ore [4]. The valorization researches of low-grade iron ores are linked with the mineralogical composition, the liberation size and the interaction between different components (iron, silica, alumina, etc.) [5]. The Low-grade iron ores can be enriched to remove gangue minerals by crushing,

grinding, gravimetric separation, magnetic separation and flotation [6, 7].

Several researchers opted to apply the dry high intensity magnetic separation aiming to enrich low-grade iron ores [4, 8-14, 16]. The results obtained by this method are satisfactory where a maximum product grade of 53.1% Fe_{Total} is achievable with 19% yield as the magnetic product in lift roll magnetic separator (LRMS) at optimum conditions of variables. Rare earth roll magnetic separator (RERMS) is also found to be efficient with a higher yield of 36.8% in the magnetic product grade of 49.5% Fe_{Total} [9]. Further, magnetic separation studies of low-grade iron ore were carried out by using LRMS and found that a product of maximum of 51.2% Fe_{Total} can be obtained from the low-grade ore assaying 35.9% Fe_{Total} [17]. An experiment on a sample contains 56.86% Fe_{Total} applying dry high intensity magnetic separation with magnetic field equal to 10A allowed to upgrade it

#Corresponding author: ali.messai@hotmail.com

doi: 10.5937/JMMA2001047M

to 65.40% [13].

In Algeria there are several mines of iron ore, and Rouina deposit is one of the oldest. Given the fact that the raw material (limonite and goethite) extracted from this mine contains high levels of silica and alumina, it is considered low-grade iron ore so it is intended for cement factories in central and western Algeria, where it is used to control Fe contents. The needs for raw material for steel industry raised a challenge for mineral processing researchers to seek for upgrading Rouina iron ore.

This study deals with a physico-chemical and mineralogical characterization of Rouina iron ores, and the choice of a treatment method adapted for obtaining a

high-grade concentrate meeting the requirements of the market, both on the contents of major and minor elements required by consumers.

2. Materials and methods

2.1. Geographic location

The ROUINA iron ore deposit is located in the Commune of Rouina, State of Ain Defla, on a dominical field. The national road connects Algiers to Oran as well as the railway line passes 3 km from the deposit, the geographical situation is presented in figure 1.

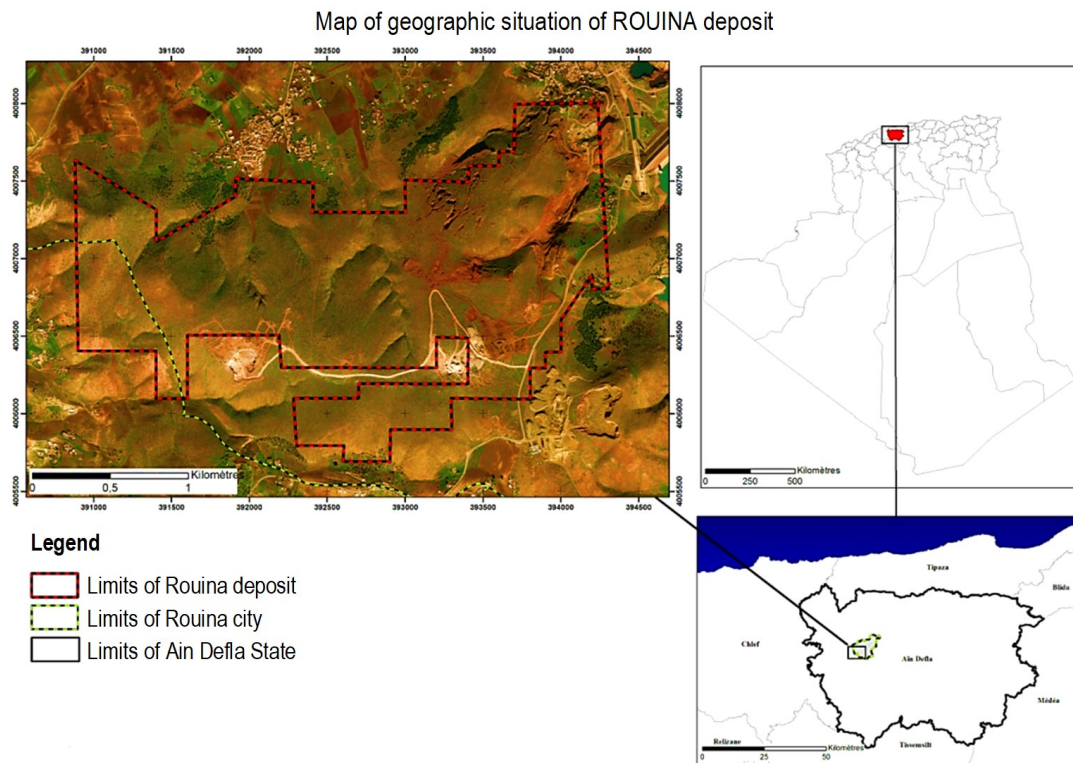


Figure 1 Geographic location of the study area

2.2. Sampling protocol

The samples of iron ores were obtained from four different points at the deposit of Rouina with a total weight of 120 kg. They were mixed repeatedly to form a representative sample. The sampling method was random, because this method ensures, as much as possible, that every unit in the lot has an equal chance of being in the sample.

a) Sampling preparation

The preparation of the samples was carried out in the Laboratory of valorization of mineral resources and environment (LAVAMINE), mining department, Badji Mokhtar - Annaba University. The collected quantity taken from the deposit of Rouina was thoroughly mixed and prepared by coning and quartering to prepare a representative samples. The samples were used for both

characterization and beneficiation studies including size distribution, physico-chemical and mineralogical analysis, washing and dry magnetic separation tests.

b) Sampling characterization

The samples were reserved to perform XRD, XRF and microscopy analysis thin sections.

The chemical analysis of raw material was carried out using a spectrometer Bruker-Axs: S8 TIGER equipped with rhodium anode.

The XRD was carried out to identify the mineral phases in the sample (raw material). It was applied using PAN analytical Diffractometer: XPERT-PRO, equipped with Copper Anticathode Ceramic X-ray Tube, the current and voltage were 40 mA, 45 kV.

2.3. Microscopy analysis

2.3.1. Optical microscopy

2.3.1.1. Thin section, polarized light

The thin sections are prepared from the whole sample. The observation of a sample thin section under polarized light (figure 2) shows the presence of xenomorphic quartz as a predominant gangue mineral (figure 2a). Many grains characterized by wavy form indicate that the mineral suffered a mechanic deformation. We note the presence of rare calcite crystals. The figure 2b shows that fine particles of hematite and limonite are dissociated in a quartz matrix. Hematite appears sometimes with important mass weakly edged by quartz (figure 2c).

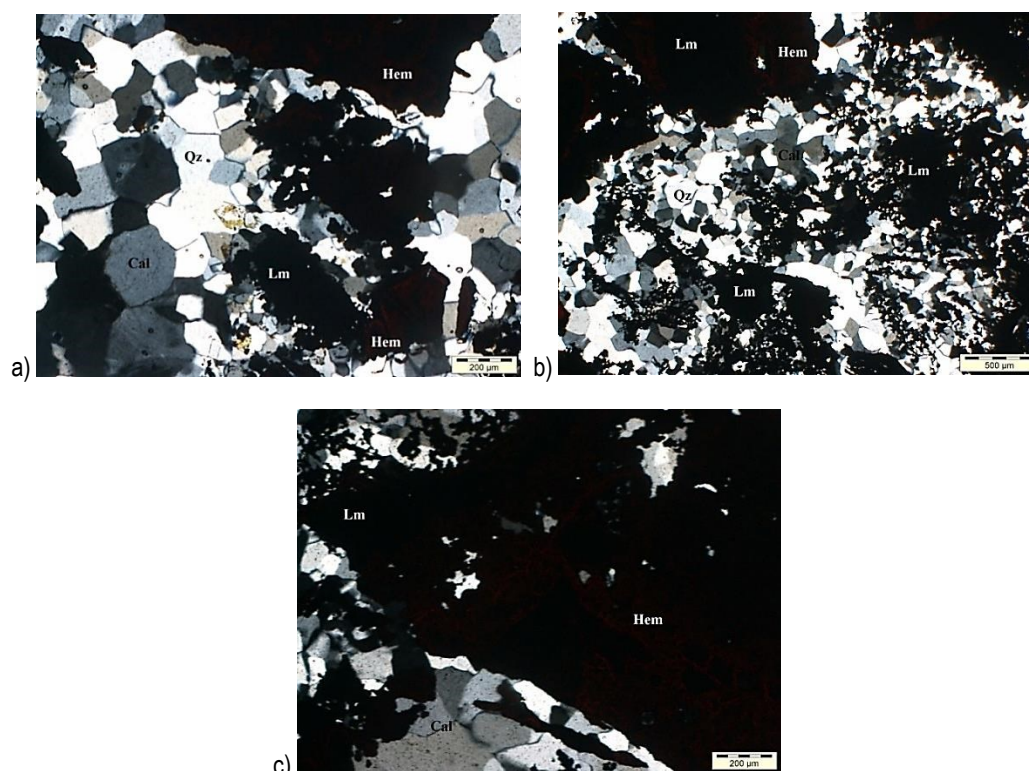


Figure 2 1st thin section under polarized light: (a) xenomorphic Quartz to undulating form associated with hematite and presence of rare calcite crystals; (b) Hematite and limonite bathing in a quartz matrix; (c) Hematite mass weakly edged by quartz; (Hem: hematite, Lm: limonite, Qz: quartz and Cal: Calcite)

2.3.1.2. Thin section, natural light

The study of 2nd thin section with natural light allowed us to notice the domination of opaque minerals (Hematite

and limonite) surrounded by quartz (figure 3a and 3b). Some opaque minerals (hematite) show oxidation traces (Limonite) which expressed by brownish spots (figure 3c and 3d).

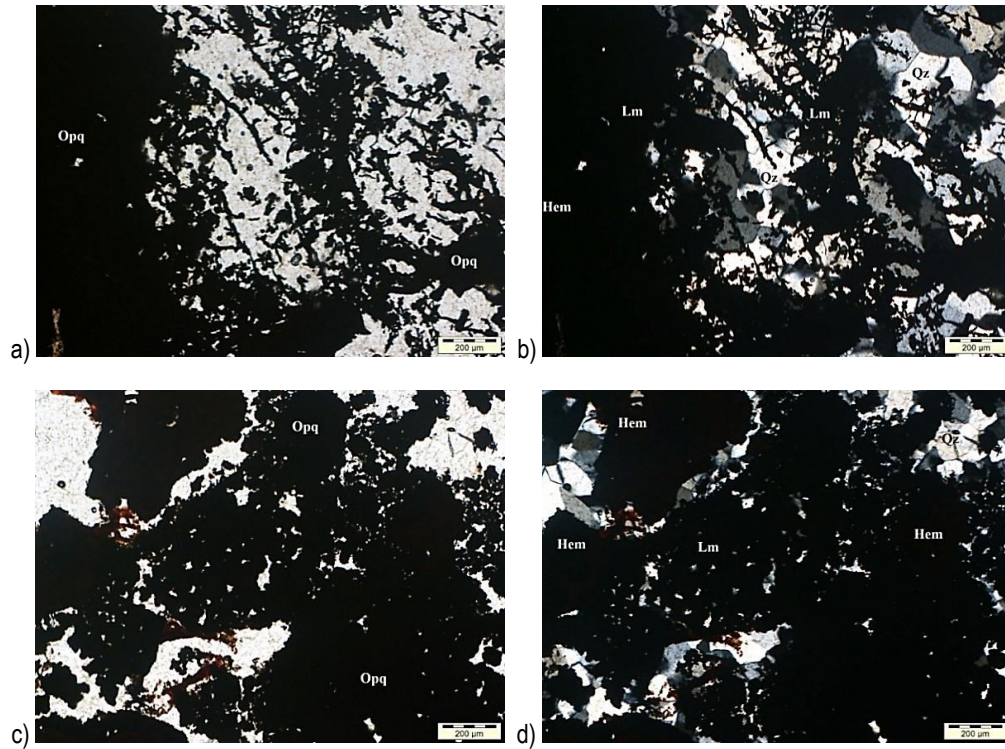


Figure 3 2nd thin section under natural light (Hem: hematite, Lm: limonite and Qz: quartz)

2.3.2. Metallographic microscopy

The observation with a metallographic microscope confirms the presence of limonite with yellow, yellow orange and yellow brownish colors as a major mineral (figure 4a). The hematite with black greenish shows a

border with a different alteration rate (figure 4b). This alteration consists in the change of color from the center of particles to the edge, from hematite to limonite (black to yellow). The blue dots indicates as air bubbles created in the thin section preparation steps.

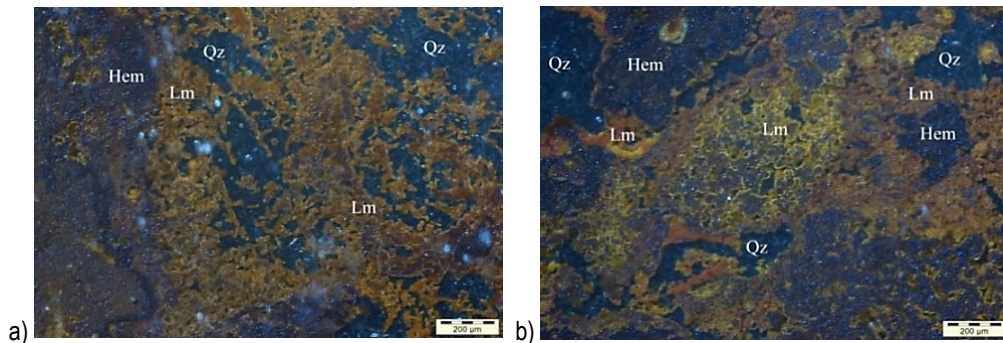


Figure 4 Microphotographs of metallographic microscope (Hem: hematite, Lm: limonite and Qz: quartz)

2.4. Sieve analysis

The size analysis was operated using quantity of 600 grams of dried raw material crushed to <4 mm, a shaking

machine type RETSCH and sieves series assembly of: 4, 2, 1, 0.5, 0.25, 0.125 and 0.063 mm. the sample is sieved for 30 minutes with magnitude of 60 mm/g. The refusal mass of each sieve is weighed using a scale with an

accuracy of 0.01g.

The results of sieving analysis are presented in Table 1. The majority mass, 46.96 w%, appears in the

coarser fraction [-5+2mm] by 46.96% (281.77 grams). The rest of product is divided in the other size fractions.

Table 1 Results of particle size analysis of Rouina iron ore crushed to 5 mm [18]

| Particle size class (mm) | Weight (g) | Yields (%) | | |
|--------------------------|------------|------------|----------------------|---------------------|
| | | Partial | Cumulative undersize | Cumulative oversize |
| +2 | 281.77 | 46.96 | 100 | 0 |
| +1 | 89.42 | 14.91 | 53.04 | 46.96 |
| +0.5 | 64.03 | 10.67 | 38.13 | 61.87 |
| +0.25 | 51.25 | 8.54 | 27.46 | 72.54 |
| +0.125 | 50.72 | 8.45 | 18.92 | 81.08 |
| +0.063 | 41.44 | 6.91 | 10.47 | 89.53 |
| +0 | 21.37 | 3.56 | 3.56 | 96.44 |
| TOTAL | 600 | 100 | / | / |

2.5. XRF analysis

The results of the analysis are shown in Table 2; we note the dominance of the iron content in the chemical composition of ore with 30.85%. The

gangue components consist of silica, alumina and calcite with 23.12%, 7.77% and 5.51% respectively. These results mean that the ore studied is a hematite – silica – clay iron ore with calcite inclusions.

Table 2 XRF Analysis of Raw material

| Fe _{Total} | SiO ₂ | Al ₂ O ₃ | CaO | MgO | P ₂ O ₅ | SO ₃ | K ₂ O | TiO ₂ | MnO | ZnO | BaO | LOI |
|---------------------|------------------|--------------------------------|------|------|-------------------------------|-----------------|------------------|------------------|------|------|------|-------|
| 30.85 | 23.12 | 7.77 | 5.51 | 1.37 | 0.12 | 0.35 | 0.95 | 0.28 | 0.32 | 0.38 | 0.76 | 14.01 |

2.6. XRD analysis

The diffractogram obtained is presented on the spectrum shown in Figure 5. It shows the dominant

presence of iron oxides (hematite and goethite) and quartz. It also shows the presence of illite in addition to calcite as minerals associated with the components of interest.

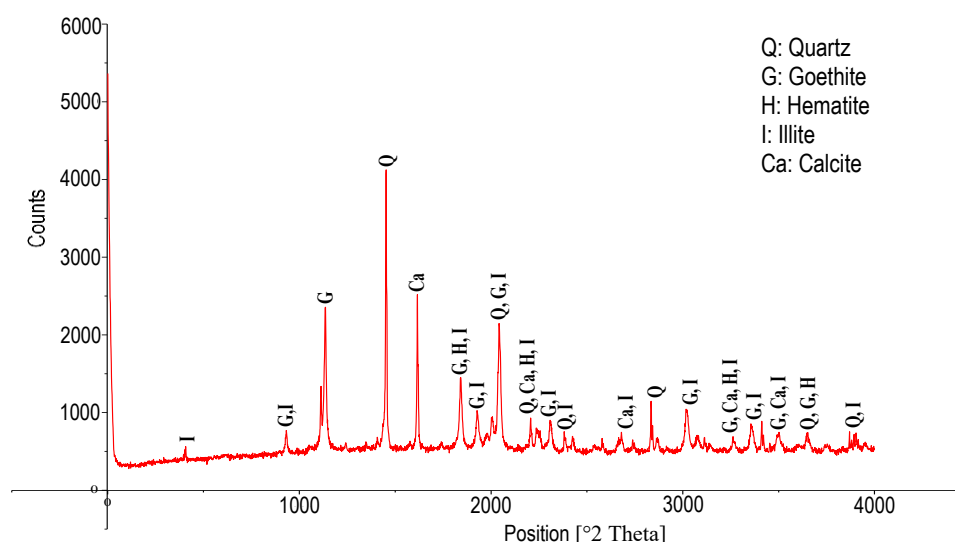


Figure 5 X-ray diffraction spectrum of Rouina iron ore (raw material)

2.7. Ore beneficiation procedure

The experimental flowsheet is shown in Figure 6 and includes procedures as follows: grinding and sieving of raw ore, washing and drying of mass passed through the sieve, and finally magnetic separation of dried product. Raw ore was ground and sieved to limit the maximum particle size to 1 mm. The portion of fine particles with sizes below 1 mm was washed with a sieve of 45 microns aperture, under water flow rate equal to 0.35 m³/h until the total cleaning of samples from clays. The retained mass of sieve was dried in an oven at 105 °C for 24

hours. The dried products were continuously fed through the hopper by vibratory feeder to an induced roll magnetic separator type 138TT42 shown in Figure 7, where the magnetic field is generated by 8 bobbins on a rotor characterized by a diameter of 100 mm and rotation speed equal to 55-60 rpm/min. the nominal power of the separator motor is 0.25 Kw. Magnetic separation tests were performed at three different magnetic field intensities (5 A = 1.4 T, 10 A = 1.9 T and 12 A = 2.4 Tesla), on samples weighing 100 grams each. The tests were repeated three times for ensuring the reliability of results.

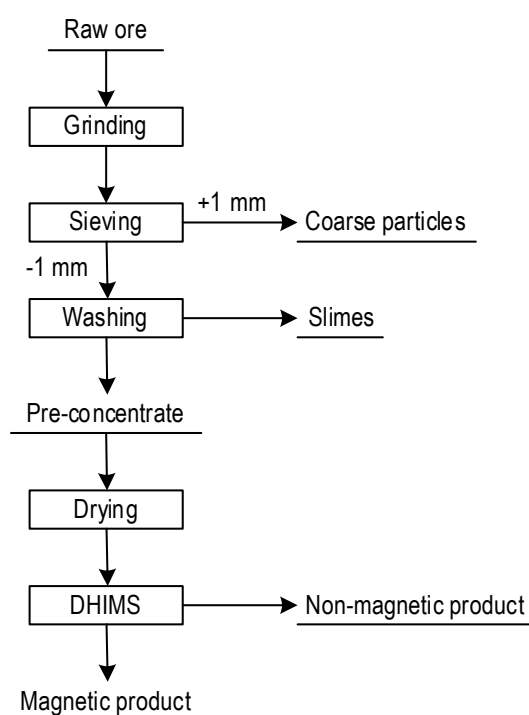


Figure 6 Diagram of experimental procedure



Figure 7 Dry high intensity magnetic separator

2.8. Statistical analysis

In order to confirm and verify the reliability of the obtained results for each experiment, a statistical model, which estimates errors of magnetic separation efficiency under different factors variation, was applied. Table 3 presents the different parameters with their formulas. It can be seen that t_α presents Student coefficient which is determined according to liberation degree (n-1) and probability associated to the confidence interval (P=95%) so $t_\alpha = 2.36$.

Table 3 Parameters and formulas of statistical modal

| Parameters | Symbols | Formulas |
|-----------------------------------|-----------------|---|
| Average grade of iron oxide | \bar{X} | $\frac{1}{n} \sum_{i=1}^n X_i$ |
| Standard deviation | S | $\sqrt{\frac{\sum_{i=1}^n (\bar{X} - X_i)^2}{n - 1}}$ |
| Sampling probable error | E | $\frac{S \times t_a}{\sqrt{n}}$ |
| Average coefficient of variation | K_{var} | $\frac{S}{\bar{X}} \times 100$ |
| Relative error | Ξ | $\frac{E}{\bar{X}} \times 100$ |
| Major average tenor of iron oxide | \bar{X}^{maj} | $\bar{X} + E$ |
| Minor average tenor of iron oxide | \bar{X}^{min} | $\bar{X} - E$ |

3. Results and discussion

3.1. Washing test results

Particle size fractions prepared by sieving analysis are subjected to washing tests. The tests were aimed at separating of useful minerals (ore

particles) from the mainly gangue of clay, calcite and quartz. It should be mentioned that each size class retained was put in a sieve suitable for carrying out the washing operation by a jet of water. The chemical analysis results of different size classes before and after washing are showed in the Table 4.

Table 4 XRF analysis of washed and unwashed products

| Fraction (mm) | Process | Fe _{Total} | SiO ₂ | Al ₂ O ₃ | CaO | MgO |
|---------------|----------------|---------------------|------------------|--------------------------------|------|------|
| -1+0.5 | before washing | 30.89 | 23.13 | 7.87 | 6.53 | 1.13 |
| | after washing | 35.68 | 20.20 | 1.45 | 7.57 | 0.40 |
| -0.5+0.25 | before washing | 30.61 | 22.26 | 6.96 | 6.22 | 1.06 |
| | after washing | 34.60 | 19.19 | 1.78 | 8.22 | 0.47 |
| -0.25+0.125 | before washing | 32.47 | 18.09 | 8.48 | 3.73 | 1.91 |
| | after washing | 36.36 | 14.81 | 1.96 | 7.69 | 0.59 |
| -0.125+0.063 | before washing | 32.43 | 18.97 | 8.55 | 3.78 | 2.13 |
| | after washing | 38.05 | 16.30 | 1.53 | 6.17 | 0.51 |
| -1+0.063 | before washing | 31.77 | 22.06 | 7.53 | 5.08 | 1.45 |
| | after washing | 35.25 | 19.25 | 1.64 | 7.62 | 0.50 |

According to the results obtained, it's indicated an increasing of iron content for all size fractions and also for the total sample [-1+0.063 mm], it's noted too a significant

decreasing of alumina to 1.45%, 1.78%, 1.96%, 1.53% and 1.64 against 7.87%, 6.96%, 8.48%, 8.55 and 7.53% in the unwashed raw material respectively.

3.2. Slimes analysis

The fines remaining after washing process of total sample [-1+0.063 mm] are analyzed by X-Ray Fluorescence (XRF) and the obtained results are shown in Table 5.

Table 5 XRF results of washing test rejects

| Fe _{Total} | SiO ₂ | Al ₂ O ₃ | CaO | MgO |
|---------------------|------------------|--------------------------------|------|------|
| 20.45 | 17.83 | 21.22 | 0.43 | 3.23 |

It can be noticed that it contains a high content of alumina and silica assaying 21.22% and 17.83%

respectively against a low content of iron which is equal to 20.45% Fe_{Total}.

3.3. Enrichment process

3.3.1. Magnetic products analysis

A series of tests on total sample and samples of different size classes at different intensities were carried out. The XRF analysis results of magnetic and non-magnetic fractions are presented in the tables 6 and 7. The tables show also the yield, and recovery degree.

Table 6 Results of magnetic separation studies of classified ore

| Size class (mm) | Intensity (T) | Detail | Yield (%) | Fe _{Total} | Fe recovery |
|-----------------|---------------|--------------|-----------|---------------------|-------------|
| -1+0.500 | 2.4 | Magnetic | 50.98 | 48.21 | 68.88 |
| | | Non-magnetic | 49.02 | 22.65 | 31.12 |
| -0.500+0.250 | | Magnetic | 52.17 | 49.49 | 74.62 |
| | | Non-magnetic | 47.83 | 18.36 | 25.38 |
| -0.250+0.125 | | Magnetic | 59.75 | 52.50 | 86.27 |
| | | Non-magnetic | 40.25 | 12.40 | 13.73 |
| -0.125+0.063 | | Magnetic | 62.82 | 54.09 | 89.30 |
| | | Non-magnetic | 37.18 | 10.95 | 10.70 |
| -1+0.500 | 1.9 | Magnetic | 50.47 | 45.67 | 64.60 |
| | | Non-magnetic | 49.53 | 25.50 | 35.40 |
| -0.500+0.250 | | Magnetic | 52.44 | 45.98 | 68.69 |
| | | Non-magnetic | 47.56 | 22.77 | 31.31 |
| -0.250+0.125 | | Magnetic | 57.55 | 48.86 | 77.33 |
| | | Non-magnetic | 42.45 | 19.41 | 22.67 |
| -0.125+0.063 | | Magnetic | 60.33 | 50.22 | 79.62 |
| | | Non-magnetic | 39.67 | 19.54 | 20.38 |
| -1+0.500 | 1.4 | Magnetic | 42.10 | 43.13 | 50.89 |
| | | Non-magnetic | 57.90 | 30.26 | 49.11 |
| -0.500+0.250 | | Magnetic | 45.19 | 44.83 | 58.55 |
| | | Non-magnetic | 54.81 | 26.16 | 41.45 |
| -0.250+0.125 | | Magnetic | 53.79 | 45.02 | 66.60 |
| | | Non-magnetic | 48.21 | 25.19 | 33.40 |
| -0.125+0.063 | | Magnetic | 54.14 | 47.11 | 67.03 |
| | | Non-magnetic | 47.86 | 26.21 | 32.97 |

of finer size fractions is due to increase in liberation degree.

The results of the tests on total sample $[-1 \pm 0.063 \text{ mm}]$ are significant, the best result obtained is at the maximum intensity of magnetic field of 2.4 Tesla where it's noted an increasing of iron content from 35.25% to 51.54% with a recovery degree of 84.52% and a yield equal to 57.81%.

| Size fraction | Intensity (T) | Detail | Yield (%) | Fe _{Total} | Fe recovery |
|---------------|---------------|--------------|-----------|---------------------|-------------|
| -1+0.063 | 2.4 | Magnetic | 57.81 | 51.54 | 84.52 |
| | | Non-magnetic | 42.02 | 12.98 | 15.48 |
| | 1.9 | Magnetic | 52.17 | 49.19 | 72.80 |
| | | Non-magnetic | 47.83 | 20.05 | 27.20 |
| | 1.4 | Magnetic | 45.25 | 46.32 | 59.46 |
| | | Non-magnetic | 54.75 | 26.10 | 40.54 |

obtained results are presented in Tables 8 and 9, it's noted that the reliability is realized for all tests where the sampling maximum error does not exceed threefold of standard deviation ($E \leq 3S$).

The statistical model was applied in order to verify the reliability of results achieved by magnetic separation. The

[illegible]

Table 9 Results of statistical analysis of total sample magnetic separation results

| Sample | -1+0.063 mm | | |
|----------------------------------|-------------|-------|-------|
| Intensity (T) | 2.4 | 1.9 | 1.4 |
| Test N°=01 | 51.24 | 49.41 | 46.25 |
| Test N°=02 | 51.60 | 49.52 | 46.39 |
| Test N°=03 | 51.33 | 49.19 | 46.89 |
| Average grade | 51.39 | 49.37 | 46.51 |
| Standard deviation | 0.19 | 0.21 | 0.34 |
| Sampling probable error | 0.26 | 0.29 | 0.46 |
| Average coefficient of variation | 0.37 | 0.41 | 0.70 |
| Relative error | 0.50 | 0.57 | 0.95 |
| Major average grade of iron | 51.65 | 49.66 | 46.97 |
| Minor average grade of iron | 51.13 | 49.08 | 46.05 |
| Number of required tests | 8 | 8 | 8 |

4. Conclusion

The investigations carried out on the low-grade iron ore issue of Rouina deposit reveal the following conclusions.

(1) The chemical analysis proved that the original sample collected from Rouina deposit is low-grade iron ore with high content of quartz and alumina where it contains 30.85% Fe_{Total}, 23.12% SiO₂ and 7.77% Al₂O₃.

(2) Regarding mineralogical characterization, the study carried out on the washed samples over thin sections and binocular observations, and with DRX, confirms that the mineral phase mainly observed is hematite-quartz-clay containing some inclusions of calcite.

(3) According to the results obtained from the chemical analysis (after the washing process by wet sieving) of the different size classes, a significant decrease in alumina content can be noticed after washing; additionally, the iron content increases up and that confirms the significant results obtained by this pre-concentration via wet sieving.

(4) Dry high-intensity magnetic separation (DHIMS) has been produced a good quality of iron ore. The best result is for the size fraction [-0.125+0.063 mm] at field intensity of 2.4 T where the iron content is increased from 38.05% to 54.09% with a recovery degree and yield equal to 89.30% and 62.82% respectively.

(5) The application of statistical model allowed estimating the errors of each experiment in order to verify the reliability of enrichment process results.

5. Acknowledgments

The author's gratefully acknowledge: Professor Hadj Zobir Souraya, Geology Department, Earth Sciences Faculty, University of Badji Mokhtar -Annaba- Algeria. Engineers of XRF, XRD and SEM at Division of Technologies and Development (DTD), SONATRACH subsidiary -Boumerdes-. Engineers and all the staff of Rouina deposit. Djabri Mohamed Tayeb, PhD student, earth sciences and architecture faculty, University of Larbi Ben M'hidi -Oum Bouaghi- Algeria and Doctor Linda Merzougui, Sociolinguistic Studies, West of Scotland University, United Kingdom for their support to conduct this research work.

6. References

- [1] Ferreira, H., Leite, M.G.P. (2015) A Life Cycle Assessment study of iron ore mining. Journal of cleaner production, 108, 1081-1091.
- [2] Nomura, T., et al. (2015) Beneficiation Plants and Pelletizing Plants for Utilizing Low Grade Iron Ore. Kobelco Technology Review 33, 8-15.
- [3] Poperechnikova, O.Y., Filippov, L.O., Shumskaya, E.N., Filippova, I.V. (2017) Intensification of the Reverse Cationic Flotation of Hematite Ores with Optimization of Process and Hydrodynamic Parameters of Flotation Cell. In Journal of Physics: Conference Series (Vol. 879, No. 1, p. 12-16).
- [4] He, J., Liu, C., Xie, J., Hong, P., Yao, Y. (2017) Beneficiation of coarse particulate iron ore by using

- a dry density-based fluidized bed separator. Powder Technology, 319, 346-355.
- [5] Rath, S.S., Dhawan, N., Rao, D.S., Das, B., Mishra, B.K. (2016) Beneficiation studies of a difficult to treat iron ore using conventional and microwave roasting. Powder Technology, 301, 1016-1024.
- [6] Jankovic, A. (2015) Developments in iron ore comminution and classification technologies. In: Iron Ore: Mineralogy, Processing and Environmental Sustainability, Woodhead publications, Elsevier, Cambridge, pp. 251–282.
- [7] Xiong, D. Lu, L. Holmes, R.J. (2015) Developments in the physical separation of iron ore: magnetic separation. In: Iron Ore: Mineralogy, Processing and Environmental Sustainability, Woodhead publications, Elsevier, Cambridge, pp. 283–307.
- [8] Tripathy, S.K., Suresh, N. (2017) Influence of particle size on dry high-intensity magnetic separation of paramagnetic mineral. Advanced Powder Technology, 28(3), 1092-1102.
- [9] Tripathy, S.K., Singh, V., Murthy, Y.R., Banerjee, P.K., Suresh, N. (2017) Influence of process parameters of dry high intensity magnetic separators on separation of hematite. International Journal of Mineral Processing, 160, 16-31.
- [10] Hosseinzadeh, M., Alizadeh, M., Raouf Hosseini, S.M. (2017) Mineralogical and physical beneficiation studies for iron extraction from Bardaskan titanomagnetite placer deposit. Journal of Mining and Environment, 8(2), 191-201.
- [11] Su, T., Chen, T., Zhang, Y., Hu, P. (2016) Selective Flocculation Enhanced Magnetic Separation of Ultrafine Disseminated Magnetite Ores. Minerals, 6(3), 86.
- [12] Qiu, T., Wu, C., Ai, G., Zhao, G., Yu, X. (2015) Effects of Multi-stage Grinding Process and Grinding Fineness on Desulfurization Separation of High-sulfurous Iron Ore. Procedia engineering, 102, 722-730.
- [13] Liu, D., Li, J.L., Wen, S.M., Wang, Y.J., Chen, Y., Cui, C. F. (2015) Beneficiation Experiment Study on Iron Ore in Yunnan Province. Applied Mechanics and Materials (Vol. 737, pp. 813-816). Trans Tech Publications.
- [14] Dwari, R.K., Rao, D.S., Reddy, P.S.R. (2014) Mineralogical and beneficiation studies of a low-grade iron ore sample. Journal of The Institution of Engineers (India): Series D, 95(2), 115-123.
- [15] Chen, C.Y., Wen, S.M., Xian, Y.J., Feng, Q.C., Zhao, H.F. (2013) Recovery of Iron from Tailings of Yangla Copper Ore by Magnetic Separation. In Advanced Materials Research (Vol. 634, pp. 3442-3445). Trans Tech Publications.
- [16] Kim, J.R., Lee, Y.S., Min, D.J., Jung, S.M., Yi, S.H. (2004) Influence of MgO and Al₂O₃ contents on viscosity of blast furnace type slags containing FeO. ISIJ international, 44(8), 1291-1297.
- [17] Tripathy, S.K., Banerjee, P.K., Suresh, N. (2014) Separation analysis of dry high intensity induced roll magnetic separator for concentration of hematite fines, Powder Technol. 264, 527–535.
- [18] Messai, A., Idres, A., Benselhouh, A. (2018) Mineralogical characterization of limonitic iron ore from the Rouina mine, Ain Defla (Algeria). Journal of Geology, Geography and Geoecology, 27(2), 305-315.

PRIMENA SUVE MAGNETNE SEPARACIJE VISOKOG INTENZITETA NA OBOGAĆIVANJE NISKOPROCENTNE RUDE GVOŽĐA IZ RUDNOG LEŽIŠTA ROUINA, ALŽIR

A. Messai^{1#}, A. Idres¹, J.M. Menendez-Aguado²

¹University of Badji Mokhtar, Faculty of Earth Sciences, Mining Department, Laboratory of Mineral Resources Valorization and Environment, Annaba, Algeria

²University of Oviedo, Polytechnic School of Mieres, Mineral Raw Materials Processing Research Group, Spain

(Primljen: 8. april 2020.; Prihvaćen: 2. jun 2020.)

Izvod

Nedavni razvoj industrije čelika i gvožđa je prouzrokovao veliku potrošnju rude gvožđa što je skrenulo pažnju na iskorišćenje resursa niskoprocentne rude gvožđa kako bi se ova sve veća potražnja zadovoljila. Ovaj rad se bavi karakterizacijom i obogaćivanjem niskoprocentne rude gvožđa iz rudnog ležišta Rouina, Ajn Delfa. Ova ruda se trenutno koristi u cementnoj industriji zato što se smatra rudom gvožđa niskog sadržaja. Nakon uzorkovanja izvršena je fizičko-hemijska i mineraloška karakterizacija. Rezultati su pokazali da se uzorci sastoje od hematita, limonita i getita kao oksidnih minerala, silikata i gline iz minerala jalovine. Prosečni sadržaj Fe_{Total} , SiO_2 i Al_2O_3 u sirovini iz rudnika koja je korišćena u istraživanju bio je 30,85%, 23,12% i 7,77%, respektivno. Postupci koji uključuju klasifikaciju, ispiranje i suvu magnetnu separaciju visokog intenziteta su sprovedeni radi obogaćivanja uzorka niskoprocentne rude gvožđa kao bi ga učinili pogodnim za tržište. Uzorak je prvo usitnjen, zatim je svaki prosejani deo ispran i osušen, i nakon toga je podvrgnut postupku suve magnetne separacije visokog intenziteta. Primećeno je da je delimično obogaćivanje rude moguće. Rezultati su pokazali da je moguće dobiti magnetni koncentrat od 54,09% sa stepenom iskorišćenja 89,30% i iskorišćenjem od 62,82% kada je jačina magnetnog polja 2,4 Tesli, a veličine frakcije $[-0,125 + 0,063 \text{ mm}]$.

Ključne reči: Rouina; Ruda gvožđa; Uzorkovanje; Karakterizacija; Ispiranje; Magnetna separacija.