MINERALOGIC AND METALLURGIC CORRELATIONS ASSOCIATED WITH IRON ORES' GRANULATED PRODUCTS[1]

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Abstract
The main objective of paper is establish correlations between metallurgic indexes of iron ore's granulated products samples, with main minerals of mineralogic assemblies described. The dates used were resulted from metallurgic tests and mineralogic descriptions of eleven samples from different iron's mines of Vale's South System. The minerals granular and sinuous hematite are proportional directely to metallization grade, decrepitation and tumbler index and presenting reverse relations with sulphur released, fine generated, reducibility and RDI. The minerals martite, lamellar hematite and goethite presenting reverse correlations with metallization grade, decrepitation and tumbler and direct relations with fine generated, sulphur release, reducibility and RDI. The metallurgic correlations with porosity are also discussed in this paper. The best knowledge of metallurgic and mineralogic correlations are important from products in the mines to steel industry, adding technologic information to raise productivity and final quality of products.
Key words: Granulated; Porosity; Mineral; Metallurgy.

CORRELAÇÕES MINERALÓGICAS E METALÚRGICAS ASSOCIADAS AOS PRODUTOS GRANULADOS DE MINÉRIO DE FERRO

Resumo
O principal objetivo do trabalho é estabelecer correlações entre os índices metalúrgicos de amostras de produtos granulados de minério de ferro, com os principais minerais da assembléia mineralógica descrita. Os dados utilizados resultaram dos testes metalúrgicos e descrições mineralógicas de onze amostras de diferentes minas de ferro do Sistema Sul da Vale. Os minerais hematita granular e sinuosa são diretamente proporcionais ao grau de metalização, crepitação e índice de tamboramento e apresentam relação inversa à liberação de enxofre, finos gerados, redutibilidade e RDI. Os minerais martita, hematita lamelar e goethita apresentam correlações inversas ao grau de metalização, crepitação e tamboramento e relação direta com os finos gerados, liberação de enxofre, redutibilidade e RDI. As correlações metalúrgicas com a porosidade são também discutidas neste trabalho. O melhor conhecimento das correlações metalúrgicas e mineralógicas são importantes desde os produtos nas minas até a indústria do aço, adicionando informações tecnológicas para o aumento da produtividade e qualidade final dos produtos.
Palavras-chave: Granulado; Porosity; Mineral; Metalurgia.

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1 INTRODUCTION

The paper comprises a better knowledge of iron ore's granulated products from mines of Vale's South System, because its production is made only by crushing and screening and higher aggregated values. The main purpose of the paper is establish some mathematic correlations between metallurgic indexes and the main minerals described in 11 (eleven) samples of iron ores' granulated products.The metallurgic tests were made according ISO norms (International Organization for Standardization): for metallization grade,[1] fine generated,[1] sulphur released,[2] relative reducibility,[3] reduction disintegration index (RDI),[4] decrepitation index[5] and tumbler index.[6] The Figure 1 shows the location of mines, object this paper.

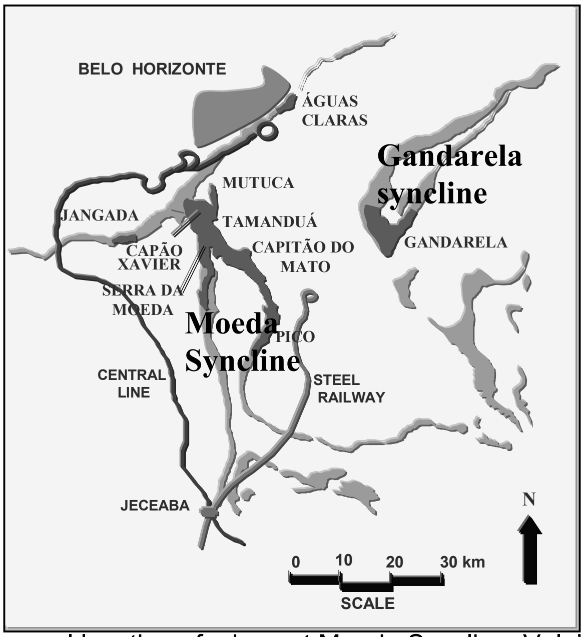

Figure 1 General location of mines at Moeda Syncline, Vale's South System.

2 MATERIALS AND METHODS

The 11 samples were collected automatically during production's shifts in a daily routine production in the processing plants of Vale's South System, using as base the NBR ISO 3082 (2003) norm[7] and the weight of each sample was 600 kg. The period of time for sampling was 6 months, because the most important thing was a higher ore's type representation for metallurgic analysis. The samples' average weights separated for metallurgic tests were 150 kg. The mineralogy was described using a optic microscope.

3 RESULTS AND DISCUSSION

The metallurgic and porosity results were organized in crescent order, objectifying a better results' interpretation, mainly the influence mineralogy's percentage. The Figure 2 shows the melallization's grades of samples, with results in crescent order. The results' variation are from 87,70 to 95,70%. The variation of granular and sinuous hematite is directly proportional to melallization's grade, as showed in Figure 3, with samples ordered the same way of metallization raise. The other minerals' group (martite, lamellar hematite and goethite) has contrary behavior, relating the same metallurgic variable (Figure 4).

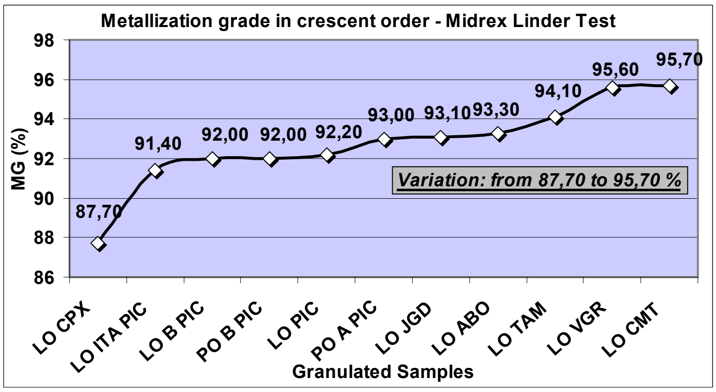

Figure 2 Results of metallization grades of granulated materials in crescent order.

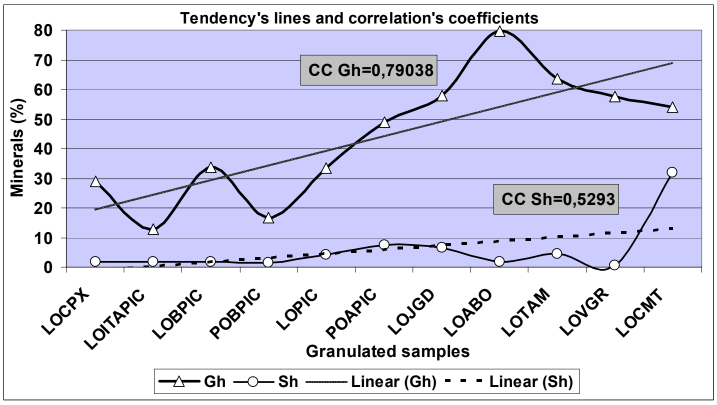

Figure 3 Tendency's lines and correlation's coefficients of granular and sinuous hematite, according metallization grades in crescent order.

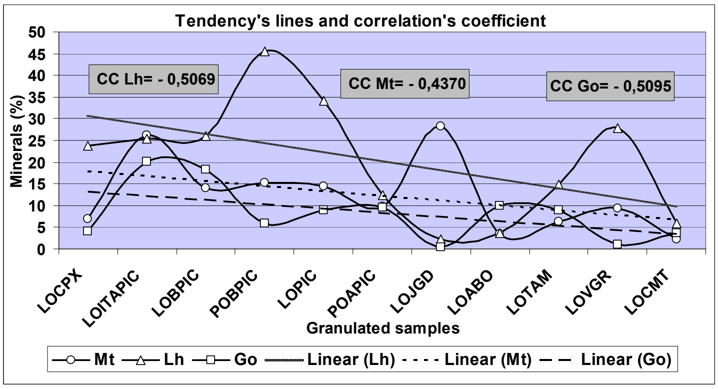

Figure 4 Tendency's lines and correlation's coefficients of martite, lamellar hematite and goethite, according metallization grades in crescent order.

The relative porosity has an inverse behavior too, in despite of low correlation coefficient, as showed in Figure 5.

The Figure 6 shows generated fines in crescent order. The Figure 7 shows granular and sinuous hematite having an inverse relation with generated fines, meaning the raise of generated fines is associated with lower percentage of these minerals. The Figure 8 shows the association of minerals group (martite, lamellar hematite and goethite) with generated fines, indicating a direct correlation, except martite. The relative porosity has an inverse relation with generated fines as showed in Figure 9.

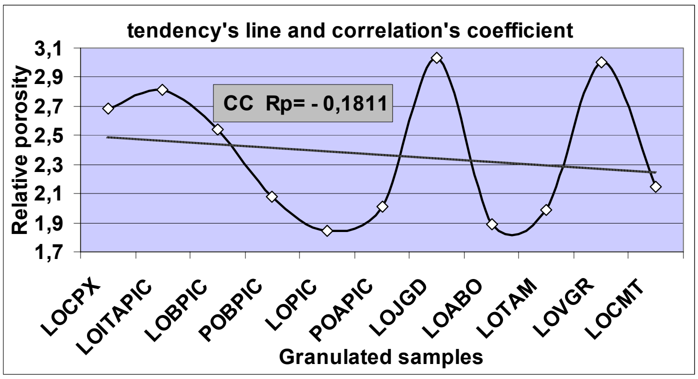

Figure 5 Tendency's lines and correlation's coefficients of porosity, according metallization's grades in crescent order (<1: porosity <10%; 1 to 2: porosity between 10 to 20%; >2: porosity higher than 20%).

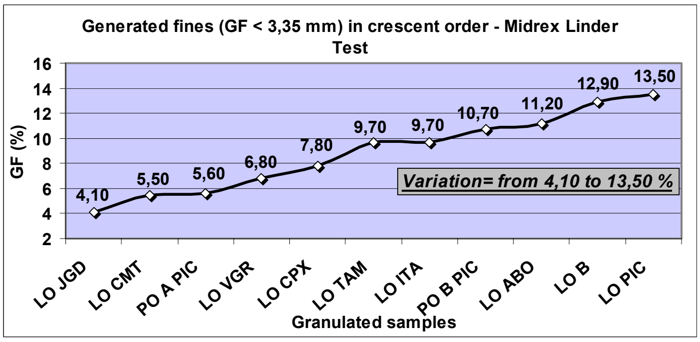

Figure 6 Results of generated fines of granulated materials in crescent order.

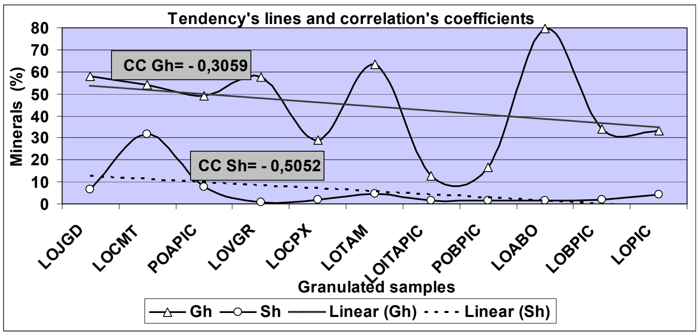

Figure 7 Tendency's lines and correlation's coefficients of granular and sinuous hematite, according generated fines in crescent order.

The sulphur released is showed in crescent order in Figure 10. The higher values are associated to products arise from alteration. The variation of granular and sinuous hematite is proportional inversely to rise of sulphur released, showed in Figure 11. The behavior of group martite, lamellar hematite and goethite is contrary, showing a direct relation in comparison with rise sulphur released (Figure 12). The relative porosity shows a high variation, but the general tendency is directly proportional to sulphur released (Figure 13), explained by ore's higher alteration grade.

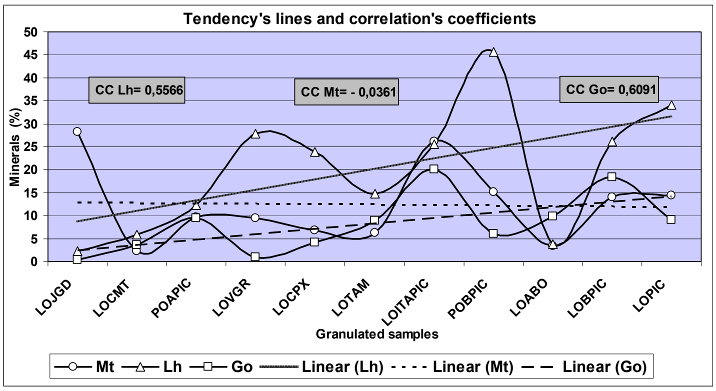

Figure 8 Tendency's lines and correlation's coefficients of martite, lamellar hematite and goethite, according generated fines in crescent order.

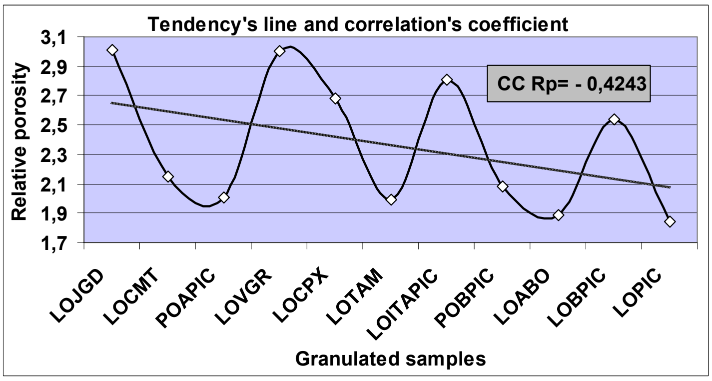

Figure 9 Tendency's lines and correlation's coefficients of porosity, according generated fines in crescent order (<1: porosity <10%; 1 to 2: porosity between 10 to 20%; >2: porosity higher than 20%).

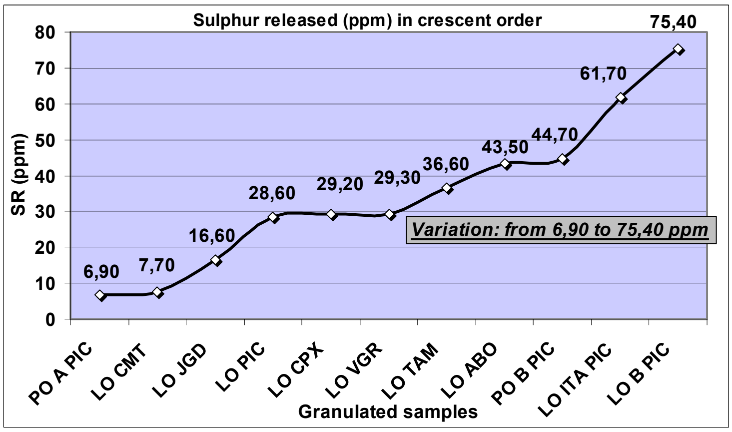

Figure 10 Results of sulphur released of granulated materials in crescent order.

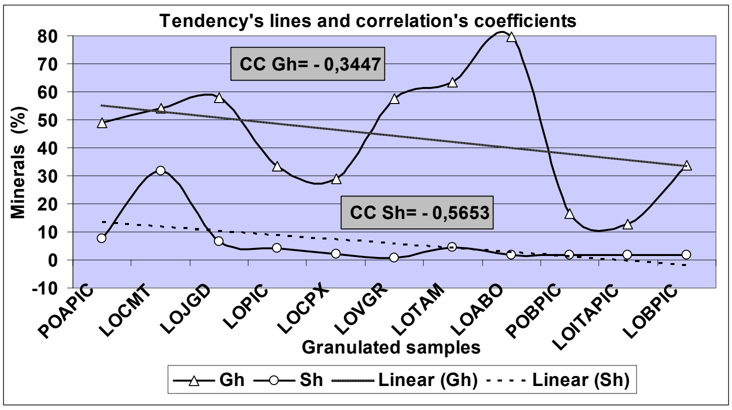

Figure 11 Tendency's lines and correlation's coefficients of granular and sinuous hematite, according sulphur released in crescent order.

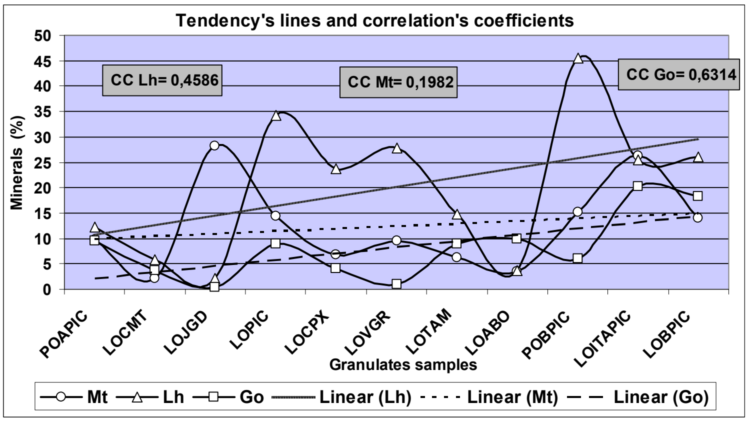

Figure 12 Tendency's lines and correlation's coefficients of martite, lamellar hematite and goethite, according sulphur released in crescent order.

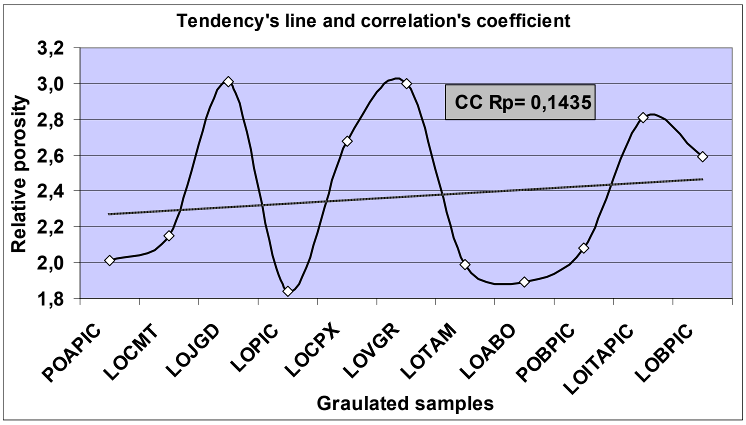

Figure 13 Tendency's lines and correlation's coefficients of porosity, according sulphur released in crescent order (<1: porosity <10%; 1 to 2: porosity between 10 to 20%; >2: porosity higher than 20%).

The Figure 14 shows the results of reducibility in crescent order. The variation of granular and sinuous hematite is proportional inversely to reducibility as showed in Figure 15. the variation of group martite, lamellar hematite and goethite is proportional directly to reducibility, showed in Figure 16 and confirming that weathered ores has higher values of reducibility. The porosity has a high variation and shows an inverse relation with reducibility, according Figure 17.

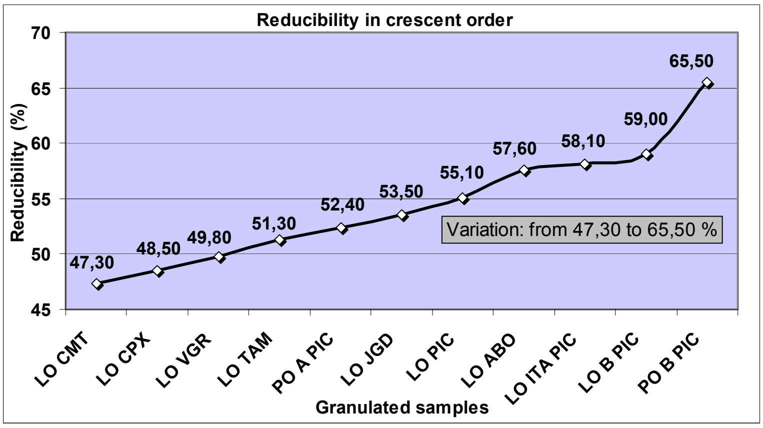

Figure 14 Results of reducibility of granulated materials in crescent order.

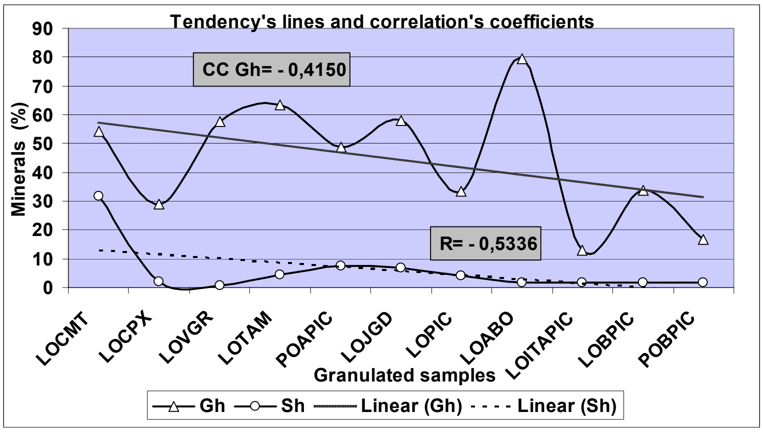

Figure 15 Tendency's lines and correlation's coefficients of granular and sinuous hematite, according reducibility in crescent order.

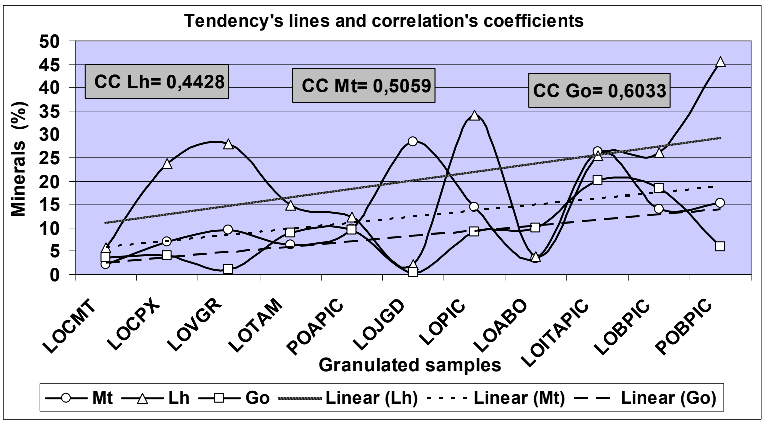

Figure 16 Tendency's lines and correlation's coefficients of martite, lamellar hematite and goethite, according reducibility in crescent order.

The Figure 18 shows the RDI's results in crescent order. The granular and sinuous hematites are proportional inversely to raise RDI's results (Figure 19). The Figure 20 shows the minerals' group (martite, lamellar hematite and goethite) presenting a direct behavior. The relative porosity presents an inverse relation, relating RDI's raise (Figure 21).

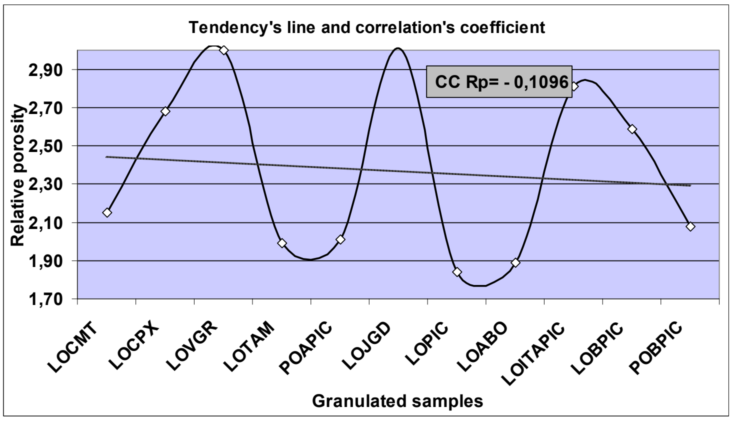

Figure 17 Tendency's lines and correlation's coefficients of porosity, according reducibility in crescent order (<1: porosity <10%; 1 to 2: porosity between 10 to 20%; >2: porosity higher than 20%).

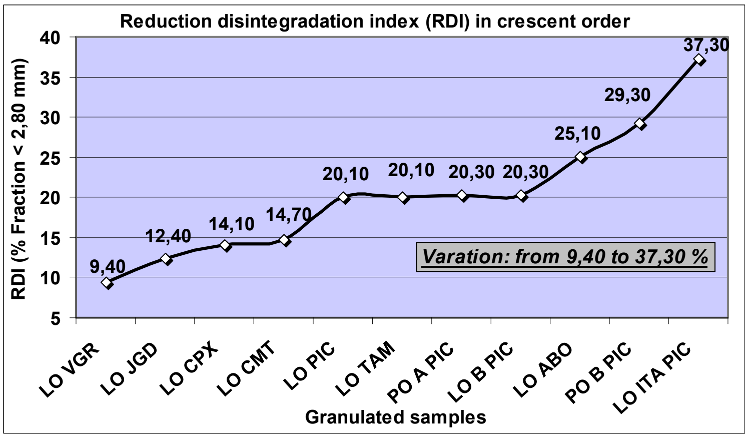

Figure 18 Results of RDI of granulated materials in crescent order.

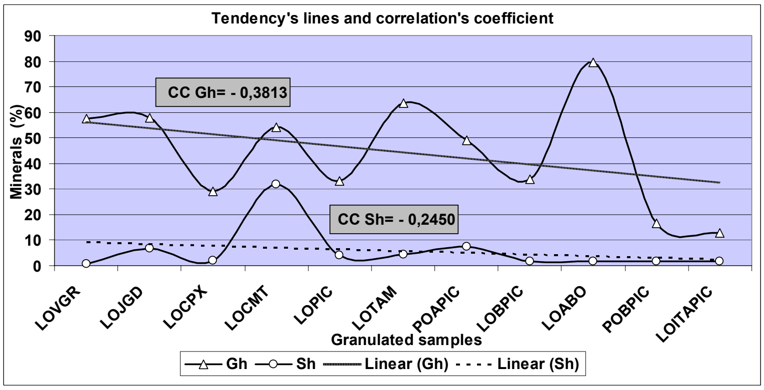

Figure 19 Tendency's lines and correlation's coefficients of granular and sinuous hematite, according RDI in crescent order.

The decrepitation index is showed in Figure 22. The granular and sinuous hematites are proportional directly to raise decrepitation index (Figure 23). The martite, lamellar hematite and goethite have an inverse relation with decrepitation (Figure 23). The relative porosity has an inverse relation with decrepitation index (Figure 24).

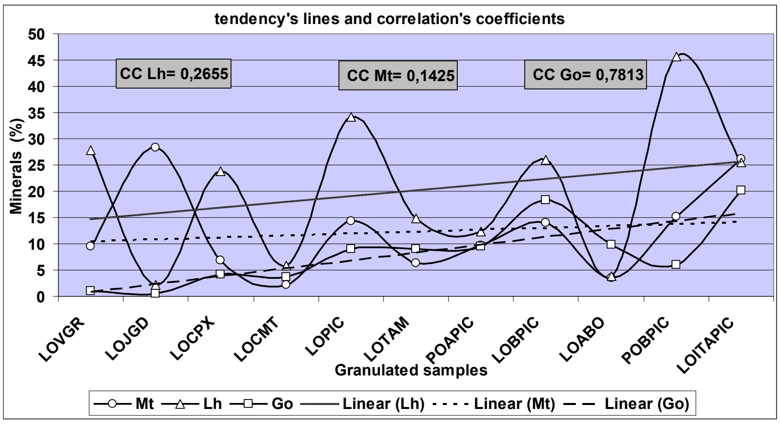

Figure 20 Tendency's lines and correlation's coefficients of martite, lamellar hematite and goethite, according RDI in crescent order.

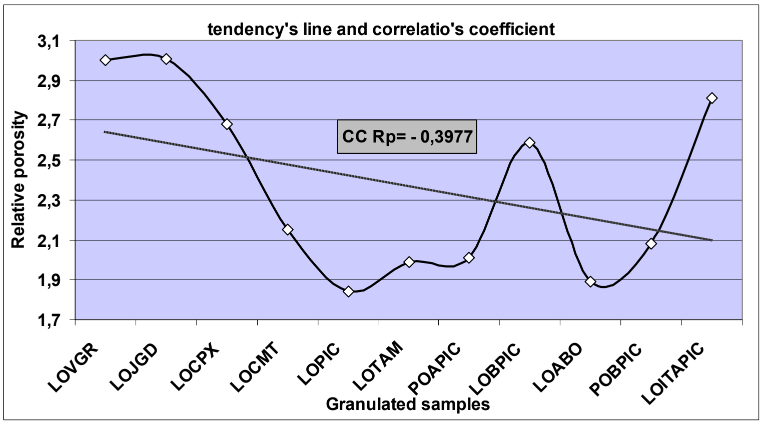

Figure 21 Tendency's lines and correlation's coefficients of porosity, according RDI in crescent order (<1: porosity <10%; 1 to 2: porosity between 10 to 20%; >2: porosity higher than 20%).

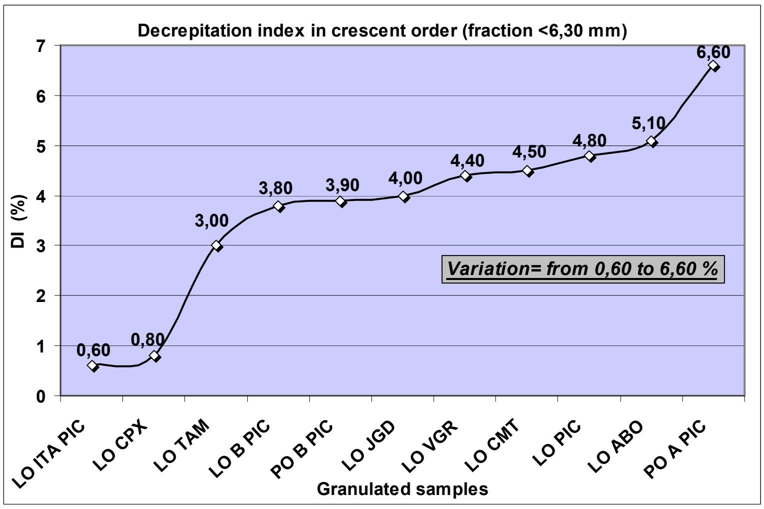

Figure 22 Results of decrepitation index of granulated materials in crescent order.

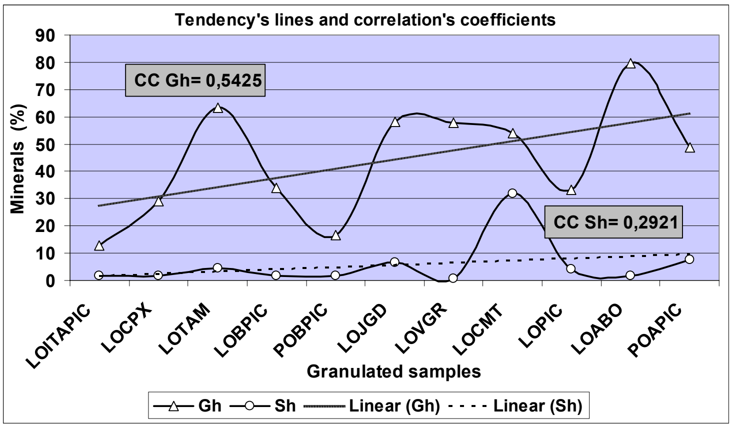

Figure 23 Tendency's lines and correlation's coefficients of granular and sinuous hematite, according decrepitation in crescent order.

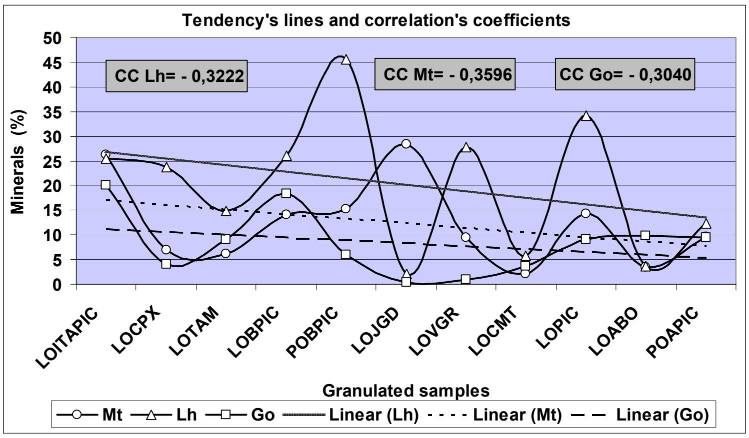

Figure 24 Tendency's lines and correlation's coefficients of martite, lamellar hematite and goethite, according decrepitation in crescent order.

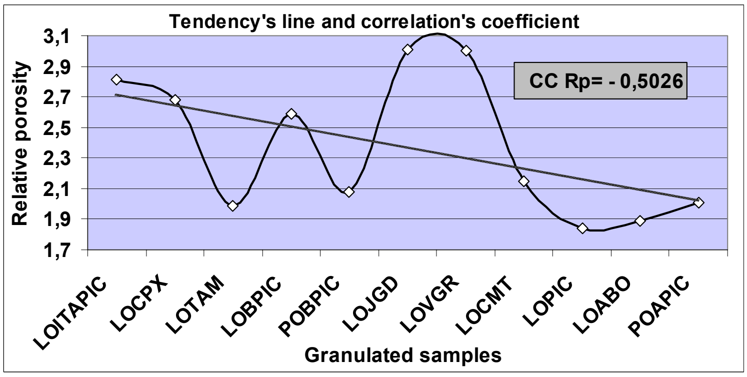

Figure 25 Tendency's lines and correlation's coefficients of porosity, according decrepitation in crescent order (<1: porosity <10%; 1 to 2: porosity between 10 to 20%; >2: porosity higher than 20%).

The results of tumbler index are showed in figure 25. The granular and sinuous hematites have a direct correlation with raise of tumbler (Figure 26). The group martite, lamellar hematite and goethite shows inverse relation with raise of tumbler (Figure 27). The relative porosity has a direct relation with tumbler index, as showed in Figure 28.

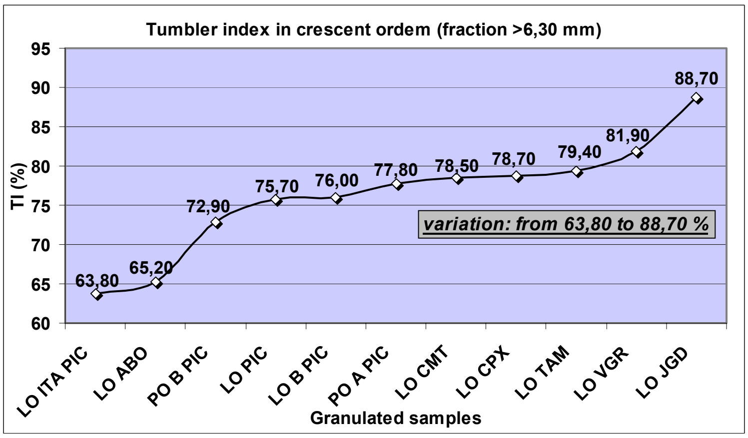

Figure 26 Results of tumbler index of granulated materials in crescent order.

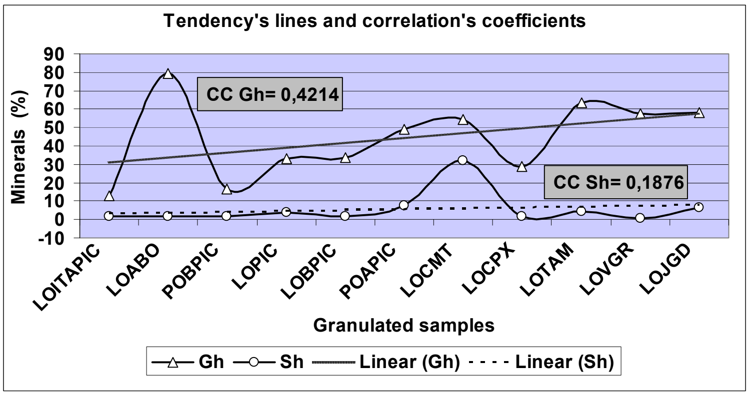

Figure 27 Tendency's lines and correlation's coefficients of granular and sinuous hematite, according tumbler in crescent order.

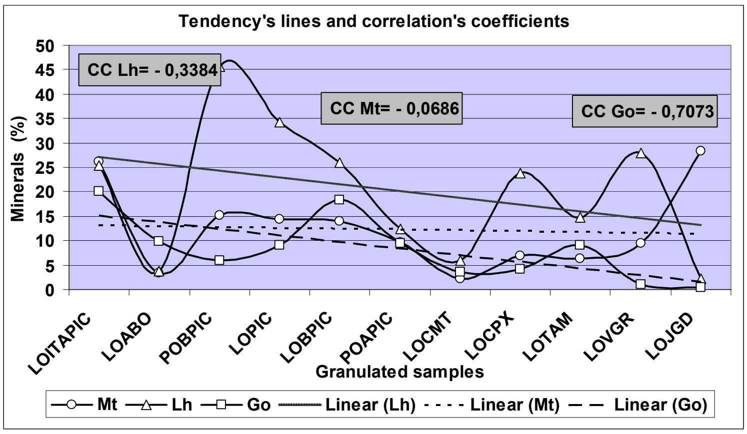

Figure 28 Tendency's lines and correlation's coefficients of martite, lamellar hematite and goethite, according tumbler in crescent order.

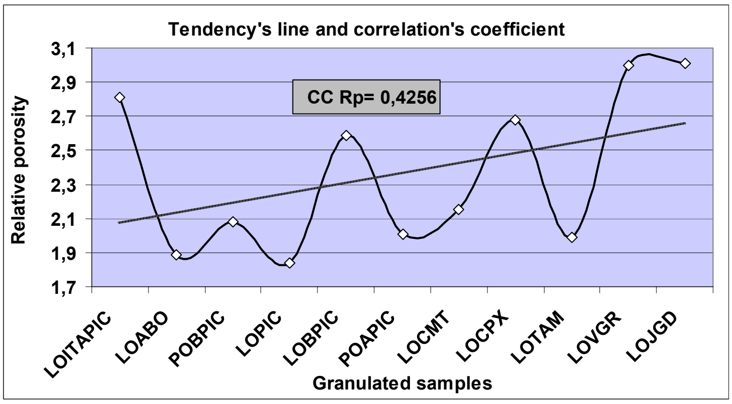

Figure 29 Tendency's lines and correlation's coefficients of porosity, according tumbler in crescent order (<1: porosity <10%; 1 to 2: porosity between 10 to 20%; >2: porosity higher than 20%).

4 CONCLUSIONS

The first conclusion is the formation of two groups of minerals, presenting different behaviors, according metallurgic indexes: 1) granular and sinuous hematites; 2) martite, lamellar hematite and goethite.

The granular and sinuous hematites are proportional directly to metallization grades, decrepitation and tumbler indexes. They have inverse relation with generated fines, sulphur released, reducibility and RDI.

The group of minerals martite, lamellar hematite and goethite are proportional inversely to metallization grades, decrepitation and tumbler indexes. They have direct relation with generated fines (except martite), sulphur released, reducibility and RDI.

The relative porosity is proportional directly to sulphur released and tumbler indexes. In terms of other metallurgic indexes, the relative porosity has an inverse relation. The variability of porosity is so high and is necessary to study in more detail this important variable, using microprobe's resolution and other methods.

The granular and sinuous hematites are associated to earlier phase of iron formation (higher temperature and pressure), while lamellar hematite was generated during structural events. Martite and goethite derived from weathered ores, with different alteration levels.

Acknowledgements

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