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Effects of Magnesium Mineral on the Reduction and Expansion Performances of Baiyun Ebo Iron Pellets

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Abstract: Pellet ore is an important raw material for blast furnace ironmaking, and its reduction and expansion performance directly affects the smooth operation and smelting indicators of the blast furnace. This paper quantitatively studied the effects of magnesium minerals such as dolomite and serpentinite on the pellet-forming performance, the microstructure after roasting, compressive strength, and the reduction expansion performance of Baiyun Ebo iron concentrate. The optimal ratio of dolomite and serpentinite to add was determined when preparing pellets using Baiyun Ebo iron concentrate powder. The results showed that the drop strength and compressive strength of the green pellet after adding serpentine were relatively higher than those after adding dolomite, indicating that controlling the MgO content in the green pellet at 2.5% using serpentine was beneficial for improving the drop strength and compressive strength. Under the condition of adding dolomite, when the MgO content was 2.5%, the compressive strength of the roasted pellet was the highest, which was 2192.6 N, and the volume expansion rate was 12.32%. Under the condition of adding serpentine, when the MgO content was 2.5%, the compressive strength of the roasted pellet was 2622.2 N, and the volume expansion rate was 9.71%. Compared with dolomite as a magnesium additive, when the reduction expansion rate of Baiyun Ebo iron concentrate was controlled within 20%, serpentine only needed to have a MgO content of about 1.5% in the pellets, while dolomite needed to have a MgO content of about 2.5%. Therefore, under the condition that the MgO contents of dolomite and serpentine were equivalent, the amount of serpentine used was lower.

Keywords: reduction; pellet; magnesium mineral; Baiyun Ebo Iron

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1. Introduction

With the development of the steel industry, the proportion of pellet ore in blast furnace raw materials is constantly increasing [1–5]. Pellet ore, as a raw material for blast furnace ironmaking or direct reduction, enters a reducing atmosphere from the moment it is added to the furnace. The reducing gases CO and H_2 in the furnace will undergo a stepwise reduction reaction from high valent iron oxide to low valent iron oxide, ultimately obtaining metallic iron [6,7]. During this reduction process, a series of complex physical and chemical changes occur in the pellets, including reduction expansion [8–10]. During the extensive use of pellet ore in blast furnaces, reduction expansion can worsen the furnace condition and affect the smooth operation of the blast furnace [11,12]. Studying the reduction and expansion behavior of pellets is of great significance for improving the smelting indicators and smooth operation of blast furnaces.

Jiang Tao et al. [13] studied the effects of CaO, SiO_2, MgO, and $A1_2O_3$ on the reduction swelling of iron ore pellets using pure iron minerals as raw materials and a pressing roasting reduction method. The results showed that the reduction expansion rate of pure hematite was obviously higher than that of pure magnetite. CaO, SiO_2, MgO, and $A1_2O_3$

could significantly reduce the reduction expansion rate of hematite pellets. Pei Henian et al. [14] studied the reduction expansion of sodium-containing hematite pellets using two different gases, CO-60% N_2 and 100% H_2, under constant temperature and heating conditions, respectively. When using CO-N_2 gas as a reducing agent for reduction, a huge phase transition stress from Fe_2O_3 to Fe_3O_4 was generated at the reaction interface under the catalytic action of sodium, causing a significant expansion of the pellets. However, when reducing with 100% H_2, the phase transition process from Fe_2O_3 to Fe_3O_4 could expand relatively gently within the full volume of the pellets, as the reduction reaction took place at or almost at the full volume of the pellets, with a smaller expansion rate. H. T. Wang et al. [15] prepared pellets at a roasting temperature of 1000 °C to investigate the effects of CaO and SiO_2 on the expansion of iron oxides and the formation of iron whiskers during the reduction process. The results showed that the effect of SiO_2 on the expansion of agglomerates was quite complex. In the case of low CaO content (0.68%), an increase in SiO_2 content could inhibit the expansion and the growth of iron whiskers. However, in the case of high CaO content (5%), the effect of SiO_2 was exactly the opposite. Although many scholars have studied the reduction expansion behaviors of pellets [16–19], there is still a lack of in-depth research on improving the raw material ratio and directly using natural minerals such as dolomite and serpentine to improve the reduction expansion behavior of pellets.

The expansion reaction occurs during the reduction process in the Baiyun Ebo mine, greatly limiting its applications in blast furnace ironmaking. Studying the effect of magnesium-containing minerals on the reduction and expansion performance of Baiyun Ebo iron concentrate pellets is of great significance for the application of all Baiyun Ebo iron concentrate pellets and the high-quality and efficient production of blast furnace ironmaking. This study takes Baiyun Ebo iron concentrate powder as the object and studies the expansion performance of pellets after adding dolomite and serpentine. Quantitative analysis is conducted on the effects of adding different proportions of dolomite and serpentine on the pellet-forming performance, mineral phase structure after roasting, compressive strength, and reduction expansion performance of pellets. The optimal ratio of adding dolomite and serpentine was determined, providing a theoretical basis for the production of pellets using Baiyun Ebo iron concentrate powder.

2. Materials and Methods

Firstly, the Baiyun Ebo iron concentrate, bentonite, and the added dolomite or serpentine were mixed in a certain proportion. Then, the pellets were pelletized on a 1 m diameter disc pelletizer, and the resulting pellets were roasted to obtain pellets with good performance. In the process of preparing pellets, the raw materials were Baiyun Ebo iron concentrate powder, bentonite, and added limestone and dolomite. The chemical compositions are shown in Tables 1 and 2. The particle size distribution of the Baiyun Ebo mine is shown in Figure 1. The particle size of bentonite, and the added dolomite or serpentine in the experiments, are below 200 mesh. Figure 2 shows the XRD analysis of Baiyun Ebo iron concentrate. In the experiments, the MgO content in the pellets was changed by adding dolomite and serpentinite, respectively. The amount of bentonite added was kept at 2%. The experiment number and plan for adding dolomite are shown in Table 3, and the experiment number and plan for adding serpentinite are shown in Table 4. The parameters during the pellet making process are shown in Table 5. These parameters are the actual process parameters of a certain steel plant. Afterwards, the drop strength and compressive strength of the prepared green pellets were measured. The falling strength was measured with 10 pellets in each group and the mean value in the 3 groups. The compressive strength of 20 green pellets in each group was measured and the mean value was taken.

Table 1. Chemical composition of Baiyun Ebo iron concentrate and bentonite, wt%. Total iron is represented by TFe.

Chemical Composition	TFe	FeO	SiO_2	MgO	CaO	Al_2O_3	K_2O	Na_2O
Baiyun Ebo Iron Concentrate	66.70	28.85	1.08	0.95	1.72	0.36	0.112	0.115
Bentonite	1.80	0.5	65.25	2.80	1.92	11.90	1.74	2.02

Table 2. Chemical composition of dolomite and serpentine, wt%. Ig represents burn loss.

Chemical Composition	SiO_2	MgO	CaO	Al_2O_3	Ig
Dolomite	2.94	23.54	34.55	0.36	37.3
Serpentine	38.51	39.34	1.56	1.12	15.2

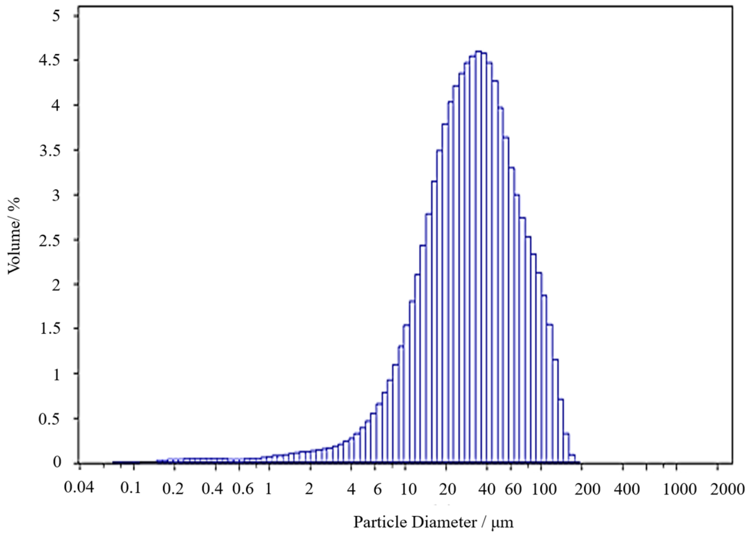

Figure 1. Particle size distributions of Baiyun Ebo iron concentrate.

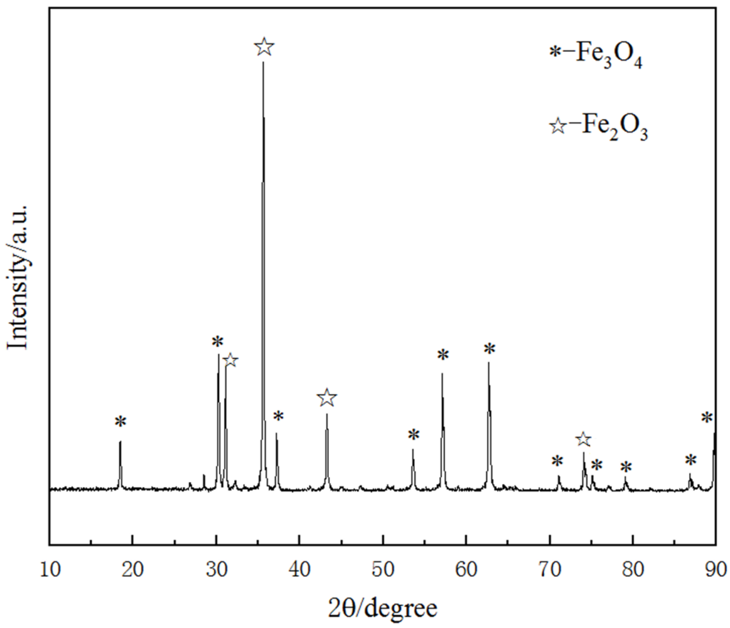

Figure 2. XRD analysis of Baiyun Ebo iron concentrate.

Table 3. Experimental plan for adding dolomite, wt%.

Sample Number	MgO Content/%	Amount of Bentonite/%
#1	1.5	2
#2	2.5	2
#3	3.5	2
#4	4.5	2

Table 4. Experimental plan for adding serpentine, wt%.

Sample Number	MgO Content/%	Amount of Bentonite/%
#5	1.5	2
#6	2.5	2
#7	3.5	2
#8	4.5	2

Table 5. Process parameters of pelletizing experiment.

Pellets' Parameters	Time/min	Disk Speed r/min
Spheroidization process	3	20
Growing up process	5	20
Compacting process	10	20

The various stages of the roasting experiment of the raw pellet were completed in a drying oven and a three-stage roasting furnace, respectively. The roasting system is shown in Table 6, below; also, these parameters are the actual process parameters of a certain steel plant. The process parameters are similar to those in the literature [20]. The compressive strength of the roasted pellet samples of each group was determined, respectively, and 20 pellets were measured at each sample point, and the average value was taken as the measurement value. At least 10 ore phase pictures were taken from edge to center under 100 and 200 times field of view, respectively, from 5 pellets at each sample point. Image analysis was performed with Micro-image Analysis and Process software (Zeiss, Jena, Germany), and the phase composition of each pellet was measured using the binary method. The pellet reduction experiment was conducted in accordance with GB/T13241-2017. After the reduction experiment was completed, the morphology and element distribution were characterized and analyzed using SEM (ZEISS, Baotou, China) and EDS (Oxford X-MaxN20, Baotou, China).

Table 6. Baking experiment process parameters.

Test Parameters	Dry	Pre-Heating 1	Pre-Heating 2	Roasting	Soaking	Cooling
Temperature/°C	300	575	975	1230	1000	Room temperature
Time/min	10	10	10	30	10	60

3. Results and Discussion

3.1. The Influence of Magnesium Minerals on the Performance of Green Pellets

Table 7 shows the effect of adding different types and proportions of magnesium minerals on the pellet-forming performance of Baiyun Ebo iron concentrate. For the green pellet sample with added dolomite, the drop strength and compressive strength of the #2 sample were relatively high, at 2.7 times and 11.2 N, respectively. For the green pellet sample with added serpentine, the drop strength and compressive strength of the #6 sample were relatively high, with 2.8 times and 14.8 N, respectively. By comparison, it can be seen that the drop strength and compressive strength of the green pellet after adding serpentine are relatively higher than those after adding dolomite, indicating that using serpentine to control the MgO content in the green pellet at 2.5% is beneficial for improving the drop strength and compressive strength. This is due to the strong water absorption of fine-grained serpentine, which has a strong adhesion effect on iron ore, thereby improving the green ball performance.

Table 7. Effects of magnesium minerals on the pellet performance of Baiyun Ebo iron concentrate.

Sample Number	Drop Intensity of Green Pellets/Time	Green Pellet Compressive Strength/N
#1	2.1	10.6
#2	2.7	11.2
#3	2.1	10.3
#4	2.2	9.8
#5	2.5	13.2
#6	2.8	14.8
#7	2.4	13.4
#8	3.1	12.4

3.2. The Influence of Magnesium on the Mineral Phase Microstructure

Figure 3 shows the mineral phase characterization of the pellet under the condition of adding dolomite. The MgO content in sample #1 is 1.5%, and its iron-containing minerals are mainly hematite, with less magnetite. The grain sizes of hematite and magnetite are smaller, and the continuity is better. The MgO content in sample #2 is 2.5%, and its grain growth is uniform and well connected. Compared with sample #1, its grain size increases. The MgO content in sample #3 is 3.5%, and the surface of the hematite begins to produce calcium ferrite, while the amount of magnetite in the ore phase decreases. The MgO content in sample #4 is 4.5%, and the magnetite content in this mineral phase is lower, with more calcium ferrite generated. Figure 4 shows the mineral phase characterization of the pellet sample under the condition of adding serpentine, which is similar to the phenomenon of adding dolomite. Under the condition of adding serpentine, the iron oxide grains are well connected, and the liquid phase is filled between the iron oxide grains, connecting them together. As the amount of serpentine added increases, the slag phase in the sample gradually increases. These slag phases wrap around the iron oxide grains, and the area where iron oxides are connected becomes larger and larger. Figure 5 shows the XRD analysis of samples with added dolomite and serpentinite.

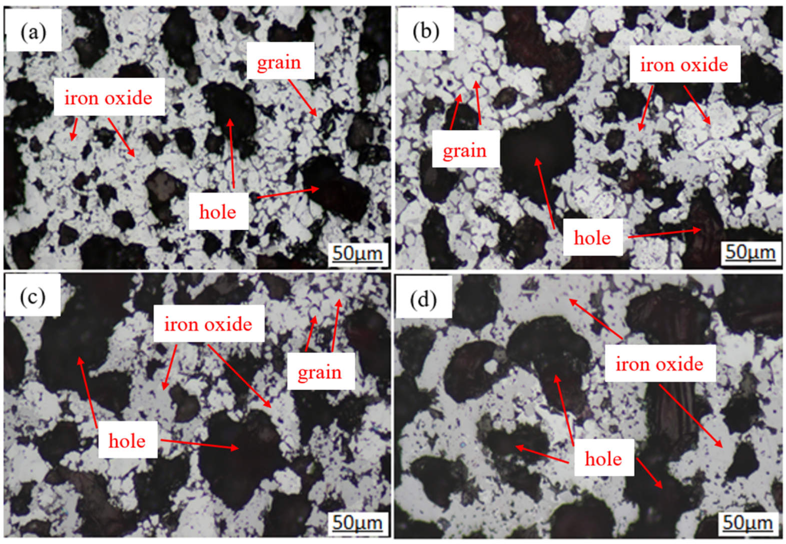

Figure 3. The images representing the mineral phases of the pellet samples #1 (**a**), #2 (**b**), #3 (**c**), and #4 (**d**).

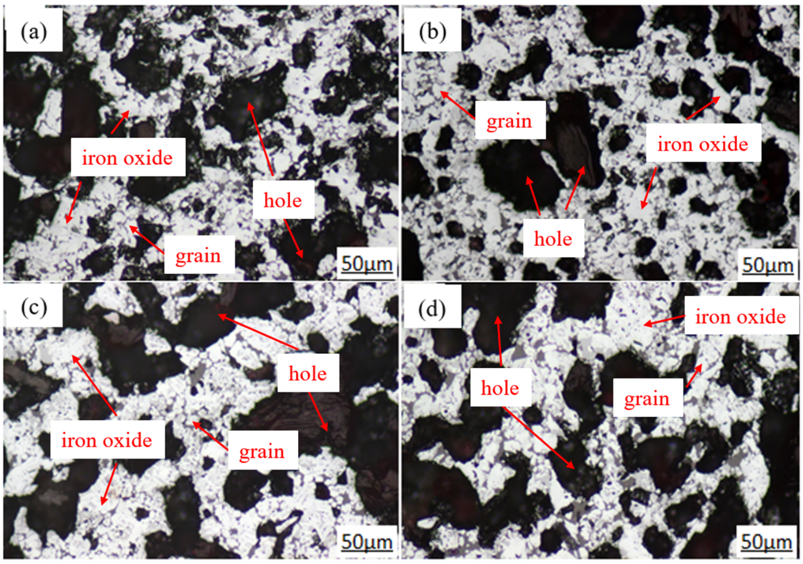

Figure 4. The images representing the mineral phases of the pellet samples #5 (**a**), #6 (**b**), #7 (**c**), and #8 (**d**).

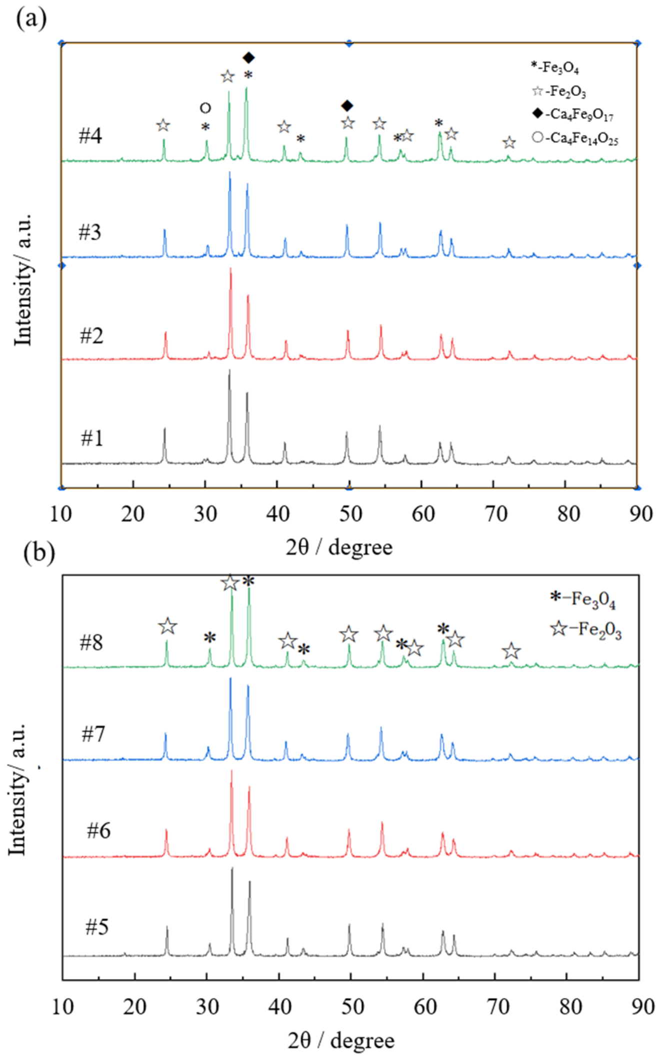

Figure 5. XRD analysis of samples with added dolomite and serpentinite (**a**) adding dolomite (**b**) adding serpertine.

To investigate the effect of adding dolomite and serpentinite on the phase composition of pellets, the phase composition of pellets under the above experimental conditions was characterized, as shown in Figures 6 and 7. As the amount of dolomite added increases, the content of hematite gradually decreases. When the MgO content is 1.5%, the content of hematite is 39.3%. When the MgO content increases to 4.5%, the content of hematite decreases to 2.5%. As the amount of dolomite added increases, the content of calcium ferrite in the mineral phase gradually increases. The appearance of calcium ferrite is mainly due to the presence of a large amount of calcium carbonate in dolomite. During the roasting process, calcium carbonate decomposes to produce calcium oxide, which reacts with hematite to produce calcium ferrite. With the increase in the dolomite addition, the amount of calcium oxide generated gradually increases, leading to an increase in the content of calcium ferrite in the pellets. As dolomite is added, the amount of gas produced by the decomposition of dolomite gradually increases, causing the porosity of the pellets to gradually increase during the roasting process, resulting in an increase in the porosity of the pellets with the increase in dolomite addition. When serpentine is added, as its content increases, the magnetite content will gradually increase. In the #5 sample with a MgO content of 1.5%, the magnetite content is 14.4%. When the MgO content increases to 4.5%, the magnetite content in the #8 sample will have already increased to 20.3%. As magnetite increases, the content of hematite decreases with the increase in serpentinite. Some serpentine will also enter the slag phase, causing the amount of the slag phase to gradually increase with the increase in serpentine addition.

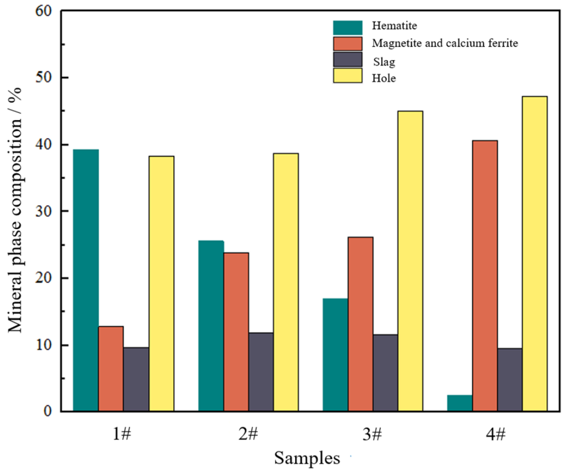

Figure 6. Mineral phase composition of Baiyun Ebo iron concentrate pellets with added dolomite.

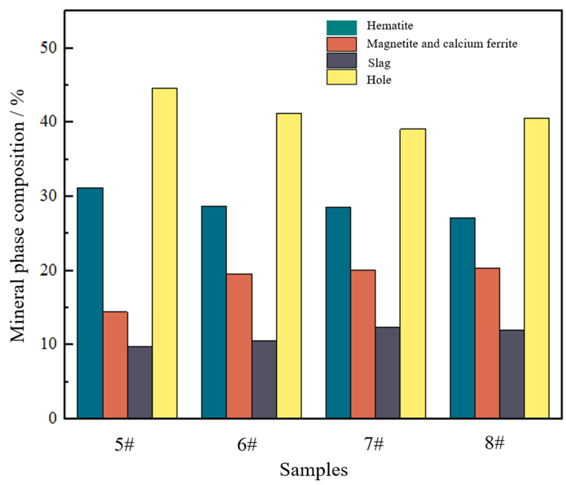

Figure 7. Mineral phase composition of Baiyun Ebo iron concentrate pellets with added serpentine.

3.3. Effect of Magnesium Mineral on Compressive Strength

Figure 8 shows the measured compressive strength of the added sintered dolomite pellets. The compressive strength of the #1 sample with a MgO content of 1.5% is 1827.8 N, while the compressive strength of the #2 sample with a MgO content of 2.5% is 2192.6 N, indicating an improvement in strength. This is because, from a microscopic perspective, the grain size of the iron oxide in sample #1 is mostly around 10 μm, while the grain size of the iron oxide in sample #2 is approximately 15 μm. The grain size of sample #2 significantly grows more fully, and the porosity of samples #1 and #2 is roughly the same. Therefore, the compressive strength of sample #2 is higher than that of sample #1. From the microstructure perspective, the pore boundaries of samples #3 and #4 become significantly smoother and the pore diameter increases compared to samples #1 and #2. The porosity of samples #3 and #4 reach 45.1% and 47.3%, respectively, resulting in a decrease in their compressive strength to around 1000 N.

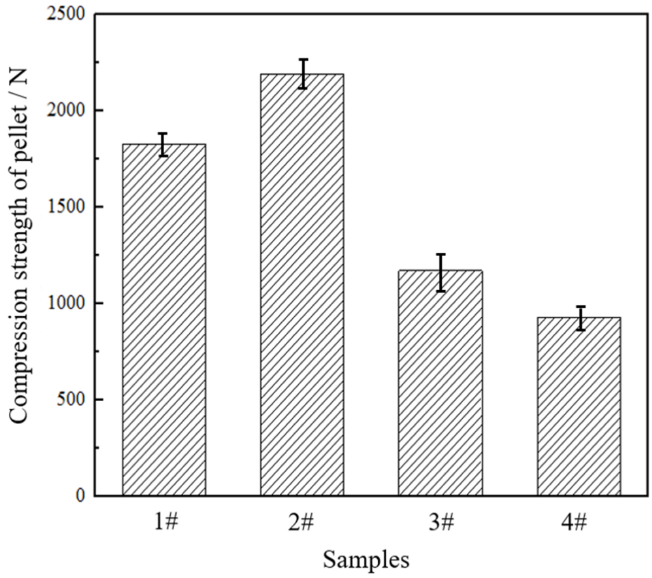

Figure 8. Compressive strength of dolomite pellets added.

Figure 9 shows the measured compressive strength of Baiyun Ebo iron concentrate pellets after adding serpentine. From the figure, it can be seen that after adding serpentine, the compressive strength of pellets with different MgO contents exceeds 2500 N, which can meet the requirements of blast furnace for pellet strength. As the amount of serpentine added increases, the compressive strength of the pellets continues to improve, mainly because the amount of slag phase increases with the increase in serpentine added. MgO increases from 1.5% to 4.5%, and the slag content increases by 2.1%, with an increase of 21.4%. At the same time, the encapsulation connectivity of slag relative to iron oxide particles is strengthened, and the ore phase microstructures of the pellets become coarser, resulting in a decrease in the porosity of the pellets and an improvement in their compressive strength.

3.4. The Influence of Magnesium Mineral on Reduction Expansion Properties

The Baiyun Ebo iron concentrate pellets with added dolomite are reduced. The microstructures of #1, #2, #3, and #4 after reduction are shown in Figure 10, and the measured reduction expansion rates are shown in Figure 11. From Figure 11, it can be seen that the #1 sample with a MgO content of only 1.5% appears to have a large number of iron whiskers after reduction, with a reduction expansion rate of up to 28.71%. This is mainly because the MgO content in the #1 sample pellet is relatively low. The hematite with good reduction ability in the roasted pellet is as high as 39.35%, while the magnetite with average reduction ability is only 12.85%. Therefore, the overall reduction ability of the #1 sample is good, and the reduction degree after reduction is high. Moreover, due to the low MgO content, the reduction expansion of the pellet is not effectively suppressed, resulting in the growth of iron whiskers, as shown in Figure 12, leading to a high reduction expansion rate and abnormal expansion. The magnetite content in the #2 sample with a MgO content of 2.5% has significantly increased, and its magnetite content is about twice that of the #1 sample, resulting in a decrease in its reducibility and a lower reduction degree. From the microstructure characterization of sample #2, it can be seen that the vast majority of iron oxide grains have not been reduced, and the reduced iron also appears to be granular, as shown in Figure 13. Therefore, the reduction expansion rate is relatively low, only 12.32%. As the MgO content continues to increase, the reduction expansion rates of samples #3 and #4 continue to decrease. This is because with the increase in dolomite addition, the CaO content in the samples also increases, resulting in the appearance of calcium ferrite during the sintering process.

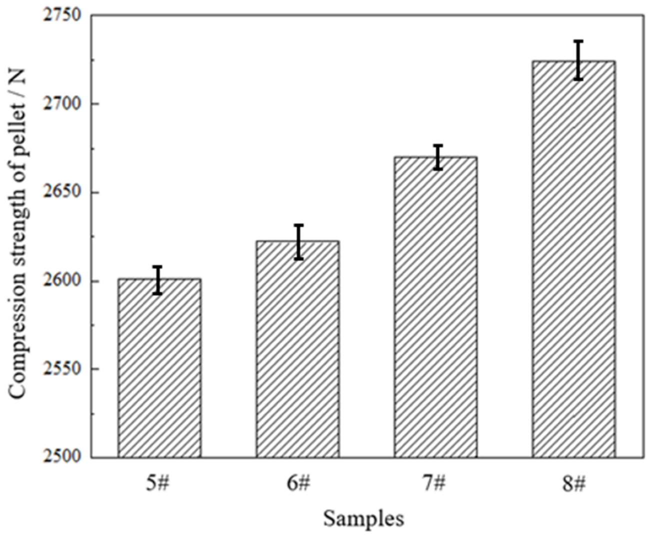

Figure 9. Compressive strength of adding Baiyun Ebo iron concentrate pellets.

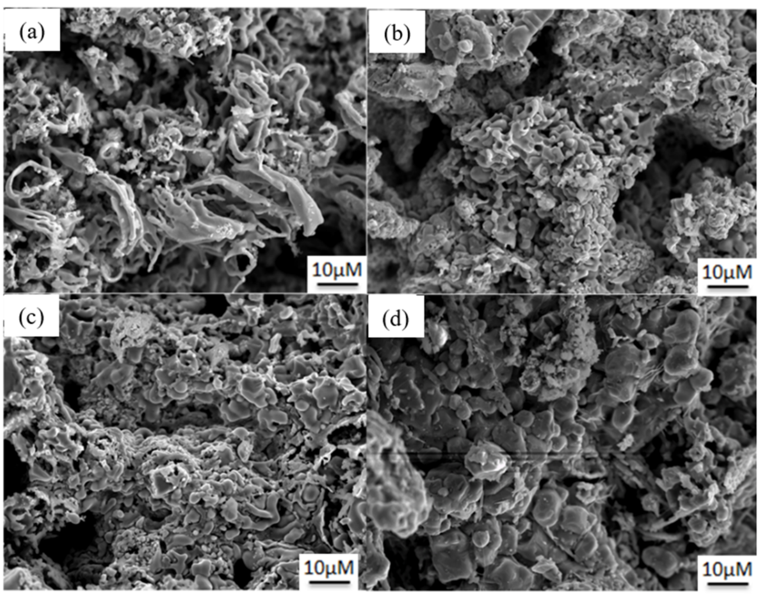

Figure 10. Microscopic morphology of Baiyun Ebo iron concentrate pellets after reduction with added dolomite (**a**) #1 (**b**) #2 (**c**) 3# (**d**) #4.

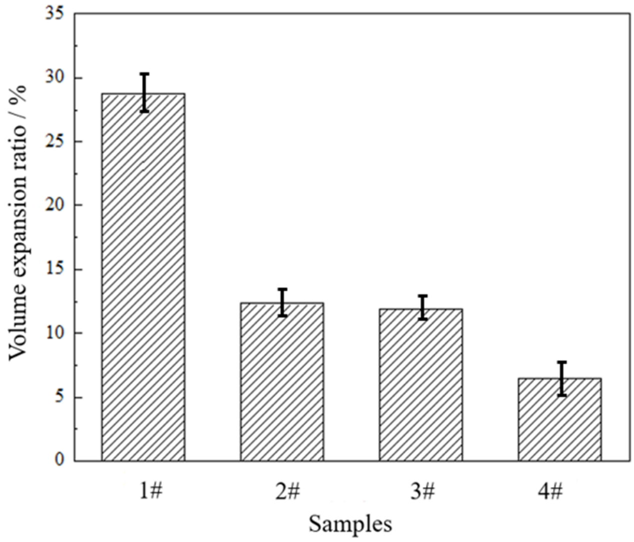

Figure 11. Reduction expansion rate of Baiyun Ebo pellet ore with added dolomite.

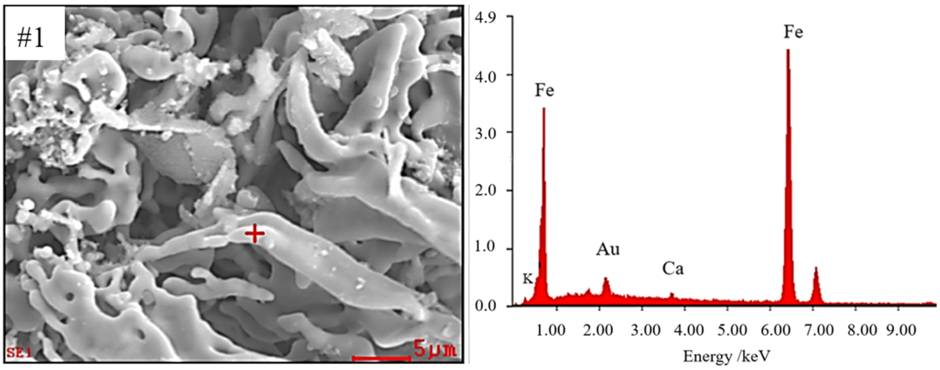

Figure 12. SEM image and EDS spectrum of iron whiskers in the #1 pellet reduction sample.

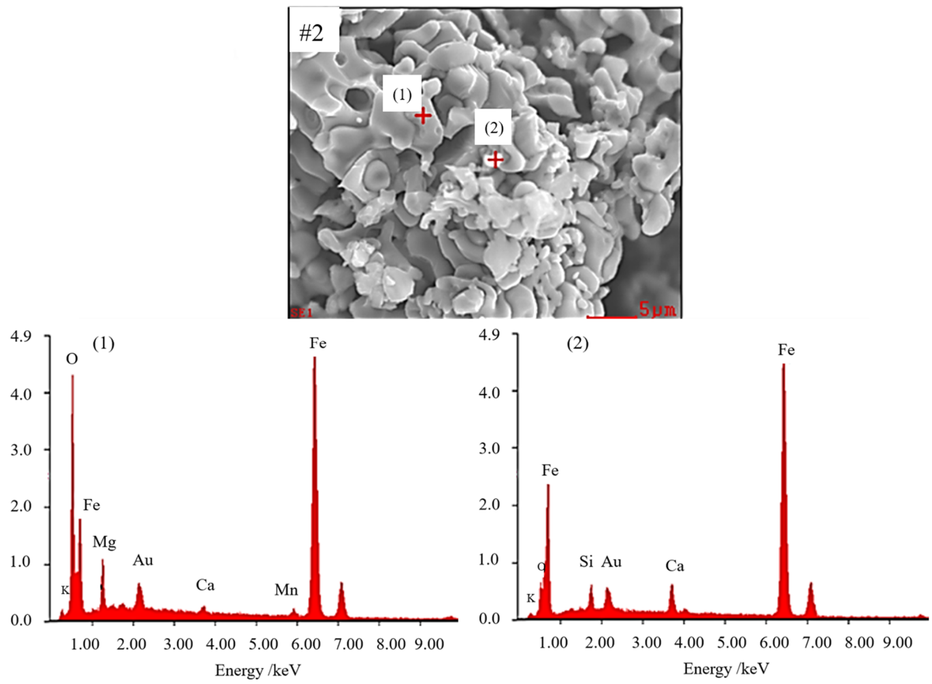

Figure 13. SEM image and EDS energy spectrum of the #2 pellet reduction sample. (1) EDS spectrum of iron oxide; (2) EDS energy spectrum of granular iron.

As the content of MgO gradually increases, the content of calcium oxide brought in by dolomite also gradually increases. Therefore, a relatively large amount of calcium ferrite appeared in the #3 sample, with a MgO content of 3.5%. The iron oxide in the #3 sample pellets is composed of hematite, calcium ferrite, and a small amount of magnetite. The reducibility of calcium ferrite is better than that of magnetite, but worse than that of hematite. The reducibility of dicalcium ferrite is equivalent to that of magnetite, and the starting reduction temperature of calcium ferrite (873 K) is higher than that of hematite (673 K). Due to the simultaneous addition of calcium oxide and MgO with dolomite in this experiment, it is easy to form magnesium-containing composite calcium ferrite (as shown in points 1 and 2 in Figure 14), which greatly reduces the reducibility of calcium ferrite and makes it difficult to reduce.

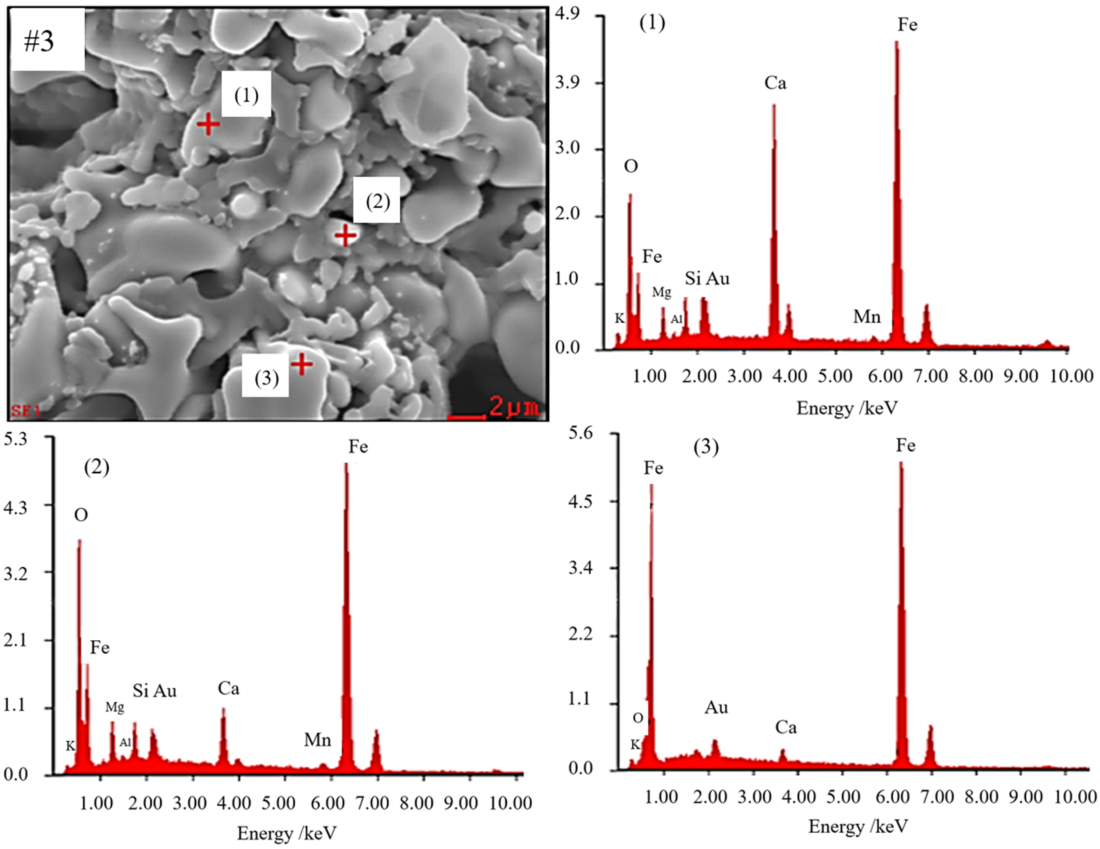

Figure 14. SEM and EDS of #3 pellet reduction sample. (1) EDS of high composite calcium ferrite iron. (2) EDS of low composite calcium ferrite iron; (3) EDS of granular iron.

In this experiment, the addition of MgO is the highest in #4, and there is a large amount of calcium ferrite in the pellets. Due to the difficulty in reducing composite calcium ferrite, both sheet-like calcium ferrite (point 1 in Figure 15) and granular calcium ferrite (point 2 in Figure 15) in the reduced pellets are not well reduced. Therefore, the reduction degree of #4 is very low, and the reduction expansion rate is only 6.49%.

From the above analysis, it can be seen that as the amount of dolomite added to the Baiyun Ebo iron concentrate increases, calcium ferrite will appear in the composition of the pellet, causing a change in the composition of the pellet ore phase, which in turn leads to a decrease in the reduction expansion rate. Adding dolomite can effectively suppress the reduction expansion of Baiyun Ebo iron concentrate pellets, but the MgO in the pellets needs to reach about 2.5% to meet the requirements of the blast furnace. At the same time, it should be noted that adding dolomite will cause a decrease in the compressive strength of the pellets. Therefore, if using dolomite as a magnesium additive to suppress the reduction expansion of Baiyun Ebo pellets, it is necessary to improve the compressive strength of the pellets from the roasting system to meet the requirements of the blast furnace for pellet strength.

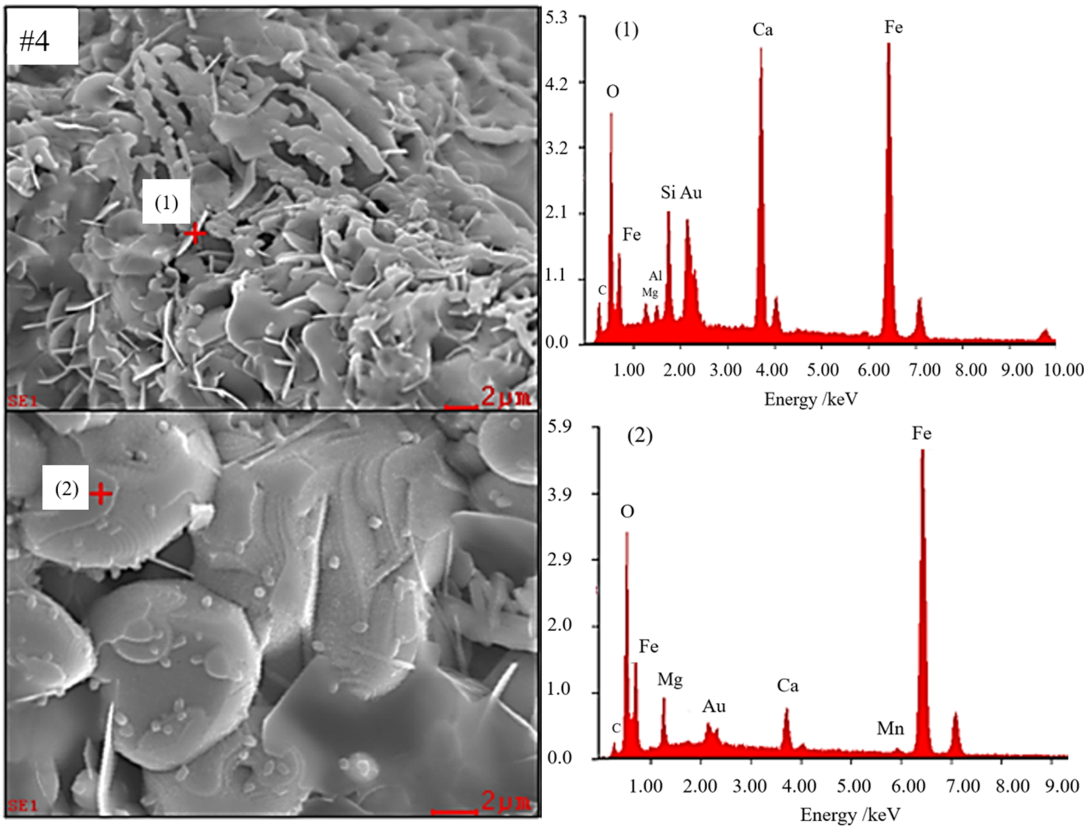

Figure 15. SEM and EDS of #4 pellet reduction sample. (1) Unreduced sheet-like calcium ferrite. (2) Unreduced granular calcium ferrite.

Serpentine is a magnesium-rich silicate mineral. By adding serpentine, the MgO in the pellets is increased, while also increasing the silicon dioxide in the pellets. MgO can react with magnetite to form magnesium ferrite or magnesium ions that enter the magnetite lattice to form magnesium-containing magnetite, stabilizing the structure of magnetite and inhibiting its oxidation, thereby increasing the magnetite content in the pellets. As a result, the hematite content in the pellets decreases, reducing the reducibility of the pellets. The added silica in the pellets or the reaction with magnetite to form olivine directly enters the slag phase, thereby increasing the amount of slag in the pellets. As the amount of slag increases, the iron oxide particles in the slag-wrapped pellets become more completely tight, which effectively hinders the contact between the reducing gas and iron oxide particles during the pellet reduction process, leading to a further decrease in the reduction performance of the pellets. Therefore, adding serpentine can effectively suppress the reduction expansion of Baiyun Ebo iron concentrate pellets. From Figure 16 of the microstructure after the reduction of the Baiyun Ebo iron concentrate pellets with added serpentine, it can be seen that no iron whiskers are reduced in images #5, #6, #7, and #8, and most of them remained in the form of iron oxides. Therefore, the reduction expansion rate is relatively low. Figure 17 shows the measured values of the reduction expansion rate of the Baiyun Ebo iron concentrate pellets with added serpentine. The reduction expansion rates of the pellets with added serpentine are all below 20%.

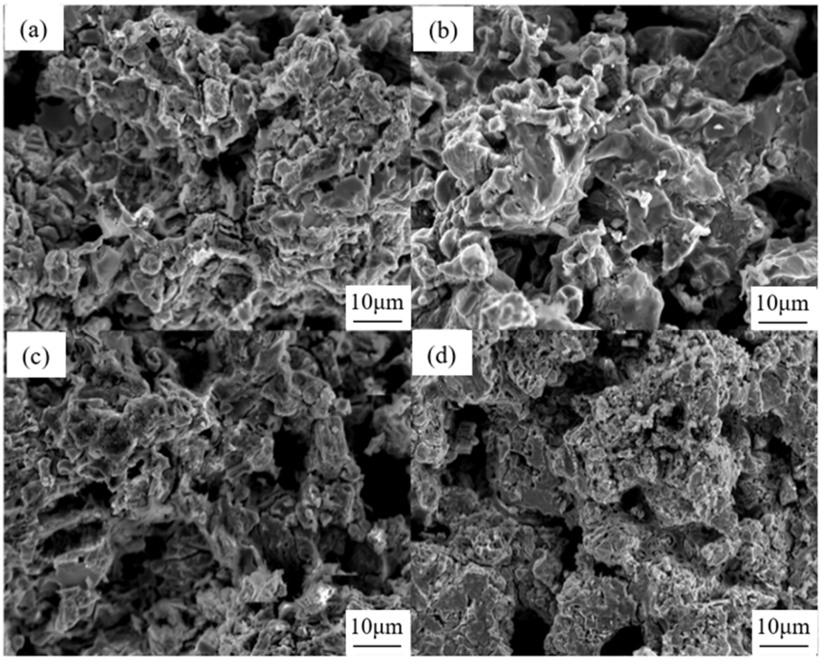

Figure 16. Microscopic morphology of Baiyun Ebo iron concentrate pellets after reduction with added serpentine (**a**) #5 (**b**) #6 (**c**) #7 (**d**) #8.

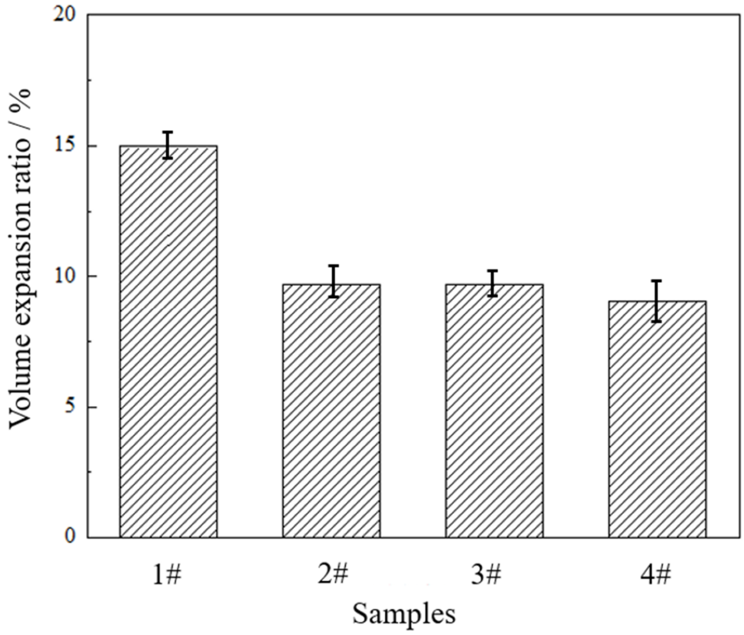

Figure 17. Reduction expansion rate of Baiyun Ebo iron concentrate pellets with added serpentine.

Figure 18 shows the SEM image and EDS energy spectrum of the #5 pellet reduction sample. From the SEM image, it can be seen that the slag phase forms a network in the pellet, which can encapsulate iron oxide particles, limiting the expansion of the pellet during the reduction process. Point 1 in the figure is a network-like silicate slag phase, and point 2 is magnesium-containing iron oxide particles encapsulated by the slag phase, and point 3 is the reduced iron oxide particles. It can be seen that the reduced iron particles are limited in the grid formed by the slag phase, resulting in a lower reduction expansion rate of sample #5, only 14.96%.

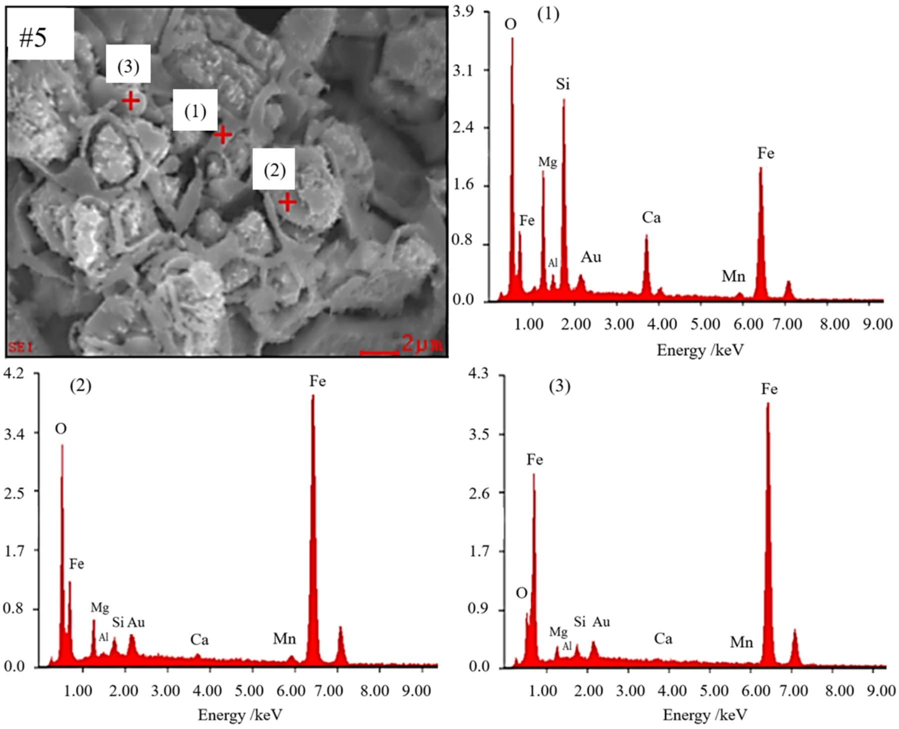

Figure 18. SEM and EDS of #5 pellet reduction sample.

Figure 19 shows the layered structure of iron oxide particles surrounded by slag phase in the sample #6 reduction. The upper and lower figures show views in two directions of the layered structure. From the energy spectrum analysis, it can be seen that these iron oxides have not been well reduced, so the reduction expansion rate is relatively low. The morphology of #7 and #6 after reduction is relatively similar, and will not be repeated.

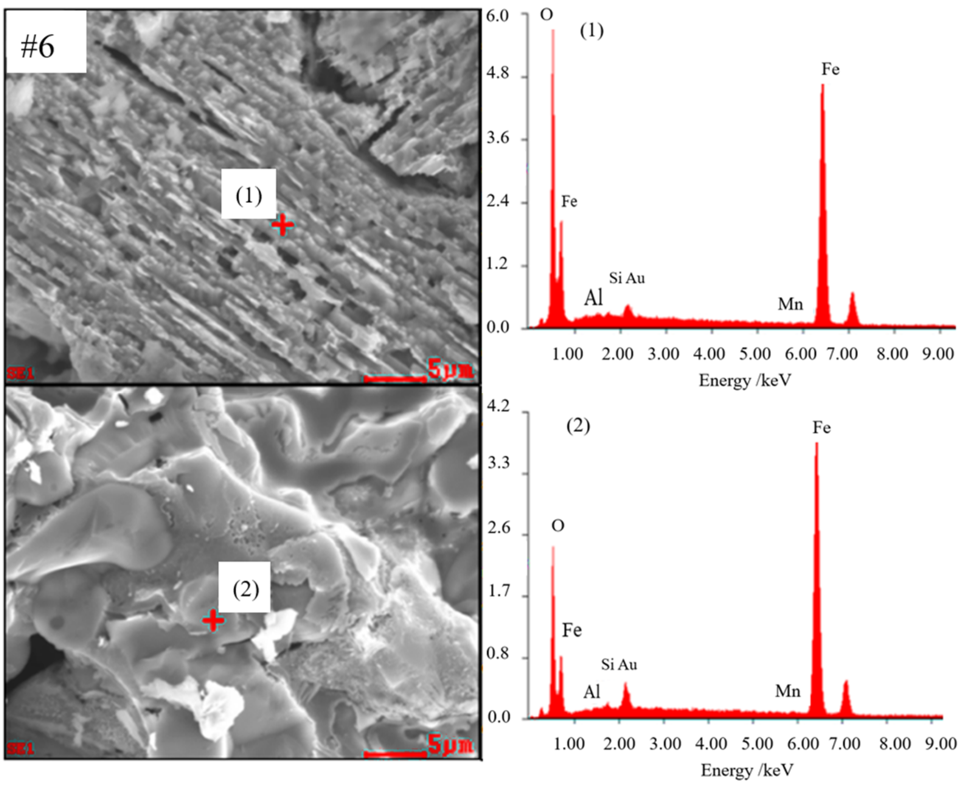

Figure 19. SEM and EDS of the #6 pellet reduction sample.

Figure 20 shows the SEM and energy spectrum of the #8 pellet sample with the most serpentine added after reduction in this experiment. The slag phase content in the pellets is also the highest, accounting for 12%. The thickness of the network-like slag film formed by the silicate slag phase in the pellet is significantly increased compared to #5, and the iron oxide particles wrapped in it are not well reduced. The thicker slag film has stronger resistance to the reduction expansion of the pellet, so the reduction expansion rate of #8 is also the smallest.

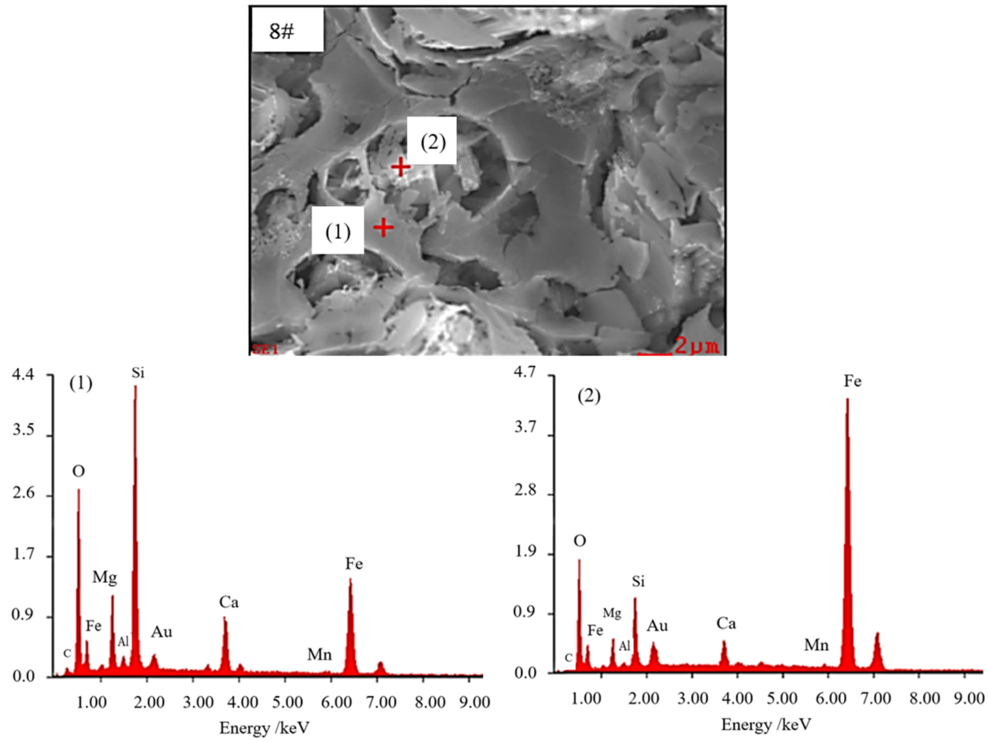

Figure 20. SEM and EDS of the sample reduced by #8 pellets.

From the results of measuring the reduction expansion rate by adding serpentine pellets, it can be seen that serpentine can effectively inhibit the reduction expansion rate of Baiyun Ebo iron concentrate pellets, and the inhibition effect is obvious. When the MgO content is 1.5%, the reduction expansion rate of pellets can be controlled below 20%, which can meet the needs of blast furnace smelting. Compared with dolomite as a magnesium additive, when the reduction expansion rate of Baiyun Ebo iron concentrate pellets is controlled within 20%, serpentine only needs to have a MgO content of about 1.5% in the pellets, while dolomite needs to have a MgO content of about 2.5% in the pellets. Therefore, under the condition that the MgO content of dolomite and serpentine is equivalent, the amount of serpentine used is lower. However, the addition of serpentine will increase the slag content of the pellets and reduce their alkalinity, which is unfavorable for reducing energy consumption in blast furnaces. The addition of dolomite can increase the alkalinity of pellets, but it can lead to a decrease in the compressive strength of pellets. Therefore, when choosing dolomite as a magnesium additive, it is necessary to adjust the roasting system to improve the compressive strength of pellets. When serpentine is used as an additive, the compressive strength of the Baiyun Ebo iron concentrate pellets can meet the requirements of the blast furnace when effectively controlling the reduction expansion of the pellets.

4. Conclusions

(1) When using dolomite as an additive for MgO, with the increase in MgO content, the amount of hematite in the pellet gradually decreases and the amount of magnetite

gradually increases. With the increase in MgO content, the porosity of the pellets gradually increases, and the slag content shows a trend of first increasing and then decreasing. When serpentine is used as an additive for MgO, with the increase in MgO content, the amount of magnetite in the pellet gradually increases, while the amount of hematite gradually decreases, and the porosity shows a downward trend, and the amount of slag phase increases.

(2) When using dolomite as an additive for MgO, the reduction expansion rate of the pellets gradually decreases with the increase in MgO content. When MgO exceeds 2.5%, difficult-to-reduce magnesium-containing calcium ferrite appears in the pellets, further reducing the reduction expansion rate of the pellets. Adding serpentine can effectively control the reduction expansion of Baiyun Ebo iron concentrate pellets. When the MgO content in the pellets is greater than 1.5%, the reduction expansion rate of the pellets is only 14.96%. Moreover, with the increase in serpentine addition, the reduction expansion rate of the pellets shows a downward trend.

(3) Compared with dolomite as a magnesium additive, when the reduction expansion rate of Baiyun Ebo iron concentrate pellets is controlled within 20%, serpentine only needs to have a MgO content of about 1.5% in the pellets, while dolomite needs to have a MgO content of about 2.5%. Therefore, under the condition that the MgO content of dolomite and serpentine is equivalent, the amount of serpentine used is lower.

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