Research and Application of High Water Content in Iron Ore

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Abstract. Iron ore is an important strategic import resource in China. Australia is the largest source of iron ore in China, with over 700 million tons of iron ore imported annually. With the increase of imports, the water content of iron ore from Australia is abnormal, generally about 8%, but in recent years, iron ore with water content higher than 10% has been repeatedly found in iron ore imported from Ningbo Port. There is even iron ore with a water content of up to 15%. Iron ore with high water content not only increases the transportation cost, but also affects the shipping safety and causes the hidden loss of iron ore tons. This paper takes 7.6% imported iron ore from Australia and 15% Australian iron ore with water content as the research object for comparative analysis. DTA method is used to analyze two kinds of iron ore with different water content to determine the water content and storage mode. The phase structure and composition of iron ore with different water content were tested by XRD. The micromorphology and micropore structure of iron ore with different water content were analyzed by SEM and the element distribution and content of iron ore with different water content were analyzed by EDS. Finally, the porosity of iron ore with different water content was tested by BET and BJH methods. Through comparative experiments, the characteristics and formation mechanism of water content of high Australian iron ore are analyzed from different angles, so that relevant technicians can grasp the formation mechanism of high water content Australian iron ore from the technical point of view, and effectively avoid hidden loss tons.

Keywords: Iron ore; Water content; Phase; porosity

1 Introduction

China is the world's largest consumer of iron ore, accounting for nearly 70% of global iron ore trade volume. In 2022, China's iron ore imports exceeded 1.1 billion tons. [1]The iron ore comes mainly from Australia, Brazil and South Africa. The import volume is respectively 729 million tons, 227 million tons, 37 million tons, accounting for 66%, 21%, 3% of the total amount of imported iron ore in our country. The moisture content of iron ore from Australia is generally within 8%, the moisture content of iron

H. Bilgin et al. (eds.), *Proceedings of the 2024 6th International Conference on Civil Engineering, Environment Resources and Energy Materials (CCESEM 2024)*, Advances in Engineering Research 253,
https://doi.org/10.2991/978-94-6463-606-2_53

ore from Brazil is generally around 5% , the moisture content of iron ore from South Africa is around 3% . Other sources of iron ore, such as India, Canada iron ore moisture content of less than 5% [3]With the increase in import volume, abnormally high moisture content has been found in iron ore imported from Australia, generally around 8%. However, in recent years, iron ore with moisture content above 10% has been frequently found in imports from Ningbo port, [8]with the highest moisture content reaching 15%. High moisture content not only increases transportation costs but also affects shipping safety and causes hidden tonnage losses. According to the international shipping rules of solid bulk cargo and TML requirements, iron ore moisture content of more than 8% .there are certain security risks. Moisture content is an important indicator for iron ore inspection and has always been a focus in international trade. According to international practice, iron ore trade is settled based on the actual weight of dry iron ore unloaded at the port of arrival. However, the actual state of iron ore at the port of arrival is in the form of iron ore with a certain amount of moisture. In practice, the weight of iron ore in its natural state at the port of arrival is usually obtained by the draft survey method, and the weight of moisture determined by inspection is deducted to finally obtain the actual weight of the dry iron ore unloaded. However, the moisture content of iron ore can be controlled during production and transportation, such as by yard storage, sun drying, clear water pumping, and cargo hold water protection measures. Some iron ore suppliers, in pursuit of improper benefits, deliberately neglect moisture control. Currently, China is in the initial stage of monitoring and evaluating high moisture content in imported iron ore. Analyzing and comparing the characteristics of high moisture iron ore from Australia, the main iron ore supplier to China, helps to understand the characteristics of high moisture iron ore from Australia, thereby providing new assessment methods for relevant regulatory personnel to determine whether high moisture content is an inherent characteristic of the mineral itself or artificially injected water for profit. At the same time, it provides technical and data support for setting related technical trade measures.

2 Experiment

The experimental materials were imported Australian iron ore with a moisture content of 7.6% and 15%. According to ISO 3082 standard[2], a batch of 102350 tons of Australian iron ore was tested, through the mechanical sampling system automatic detection: [12] the delivery of the average moisture content of 7.6% of the sample for the test samples. [13]According to ISO 3082 standard, a batch of 152900 tons of Australian iron ore was tested, through the mechanical sampling system automatic detection: the delivery of the average moisture content of 15% of the sample for the test samples. A comparative experimental study was carried out. [4]The iron ore sample with a moisture content of 15% was marked as: More; the iron ore sample with a moisture content of 7.6% was marked as: Less. The DTA method was used to analyze the relationship between temperature and weight of the two types of iron ore; the XRD method was used to analyze and test the phase structure and composition of iron ore with different moisture contents; SEM was used to observe the micromorphology and micropore structure of the two types of iron ore with different moisture contents; [11] EDS was used to analyze the elemental distribution and content of the two types of iron ore with different moisture contents; finally, the BET and BJH methods were used to test and analyze the porosity of iron ore with different moisture contents. The BET, XRD, and SEM experimental samples were samples of Australian iron ore with a moisture content of 7.6% (Less) and 15% (More) after drying at 105°C for 8 hours. The DTA samples were the original samples of Australian iron ore with a moisture content of 7.6% (Less) and 15% (More), and the test conditions were: high-purity oxygen (50mL/min), heating rate of 10K/min, temperature range of 30-1200°C. XRD test conditions: 10-90°, scanning rate of 2.35°/min.

2.1 DTA Experimental Method

2.1.1 Materials.
Sample 1 Less: Australian iron ore with a moisture content of 7.6%
Sample 2 More: Australian iron ore with a moisture content of 15%

2.1.2 Experimental Results.

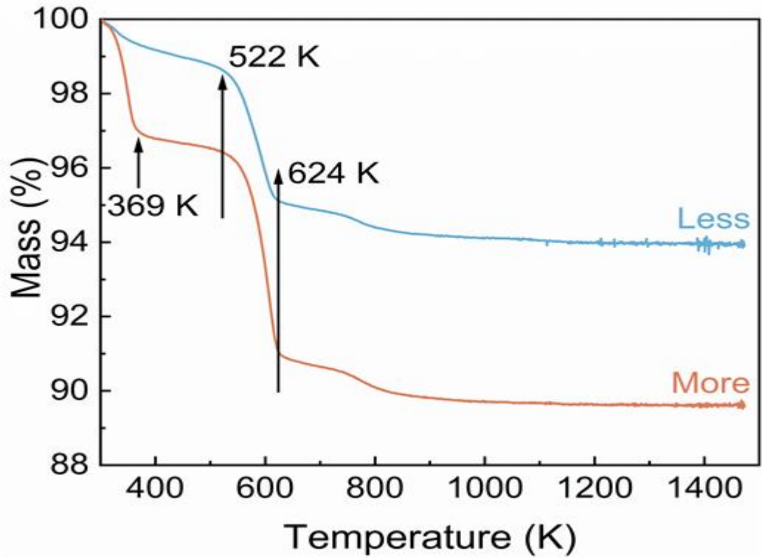


Fig. 1. Thermal gravimetric curve change diagram of two types of iron ore with different moisture contents

2.2 XRD Experimental Method

2.2.1 Materials.
Sample 1 Less: Australian iron ore with a moisture content of 7.6%
Sample 2 More: Australian iron ore with a moisture content of 15%

2.2.2 Experimental Results.

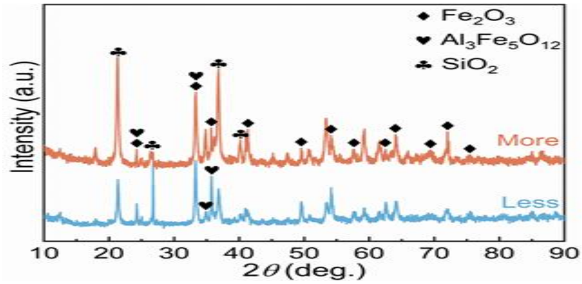


Fig. 2. XRD analysis comparison diagram

2.3 SEM Experimental Method

2.3.1 Materials.

Sample 1 Less: Australian iron ore with a moisture content of 7.6%

Sample 2 More: Australian iron ore with a moisture content of 15%

2.3.2 Experimental Results.

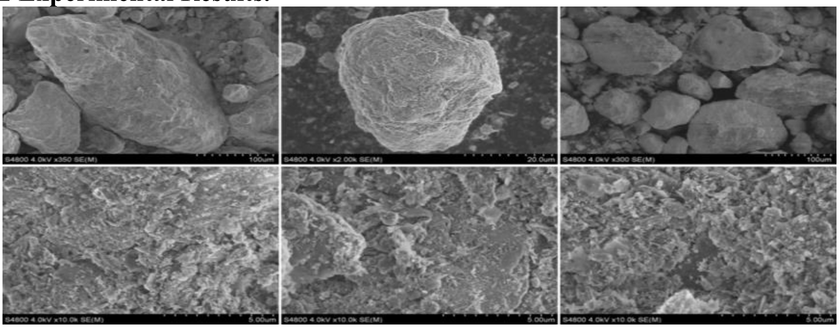


Fig. 3. SEM image of Australian iron ore with a moisture content of 7.6%

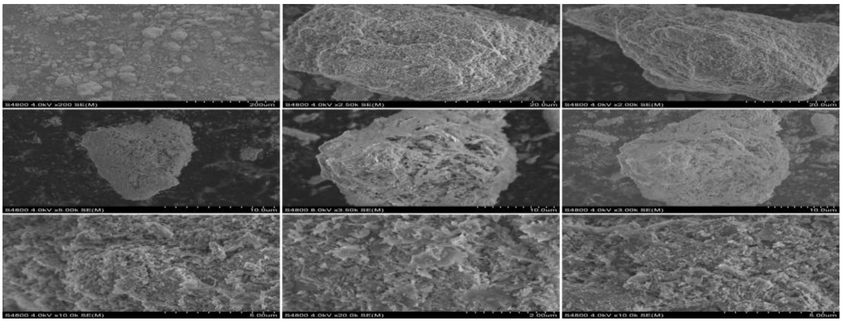


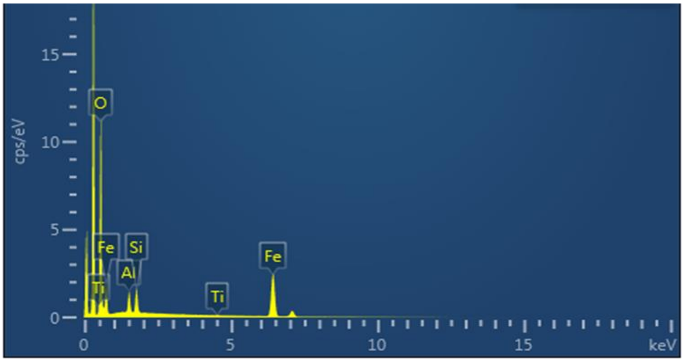
Fig. 4. SEM image of Australian iron ore with a moisture content of 15%

2.4 EDS Experimental Method

2.4.1 Materials.

Sample 1 Less: Australian iron ore with a moisture content of 7.6%
Sample 2 More: Australian iron ore with a moisture content of 15%

2.4.2 Experimental Results.



(Area spectrum)

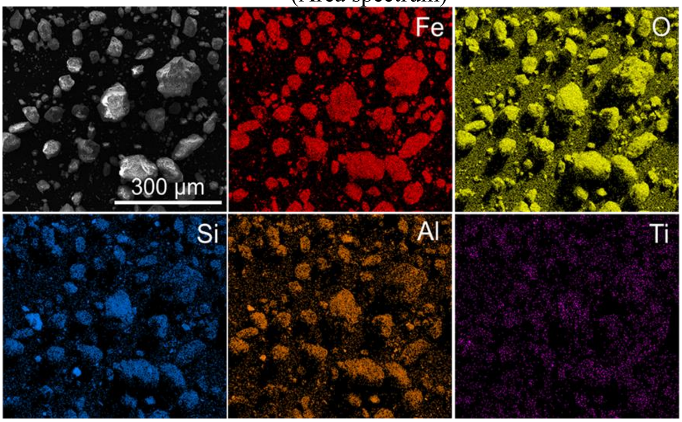
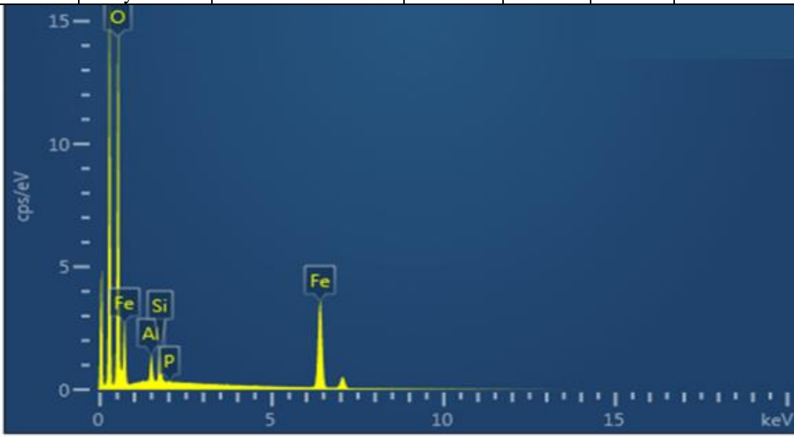


Fig. 5. EDS analysis diagram of Australian iron ore with a moisture content of 7.6%

Table 1. EDS results and test parameters of each element in Fig.5

Element	LineType	Apparent con-centtration	K ration	wt%	wt% Sigma	Standard sample label
O	K-Line system	16.68	0.05613	36.10	0.12	SiO2
Al	K-Line system	0.72	0.00514	3.99	0.05	AL2O3
Si	K-Line system	0.85	0.00675	4.33	0.05	SiO2
Ti	K-Line	0.04	0.00037	0.17	0.04	Ti

	system					
Fe	K-Line system	11.41	0.11413	55.41	0.14	Fe
Total amount	K-Line system			100.00		



(Area spectrum)

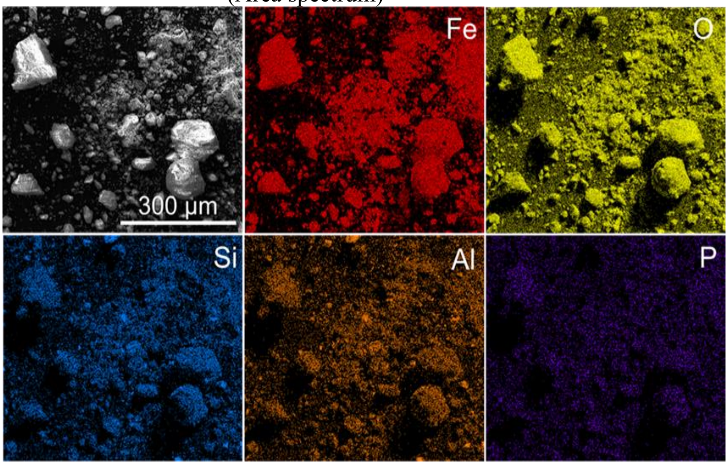


Fig. 6. EDS analysis diagram of Australian iron ore with a moisture content of 15%

Table 2. EDS results and test parameters of each element in Fig.6

Element	LineType	Apparent concenttration	K ration	wt%	wt% Sigma	Atomic percentage	Standard sample label
O	K-Line system	21.81	0.07341	34.58	0.10	62.76	SiO2
Al	K-Line system	0.66	0.00476	2.82	0.04	3.03	AL2O3
Si	K-Line	0.81	0.00643	3.10	0.03	3.21	SiO2

	system						
P	K-Line system	0.06	0.00032	0.14	0.02	0.13	GaP
Fe	K-Line system	16.43	0.16427	59.37	0.11	30.87	Fe
Total amount				100.00		100.00	

2.5 BET and BJH Experimental Method

2.5.1 Materials.

Sample 1 Less: Australian iron ore with a moisture content of 7.6%

Sample 2 More: Australian iron ore with a moisture content of 15%

2.5.2 Experimental Results.

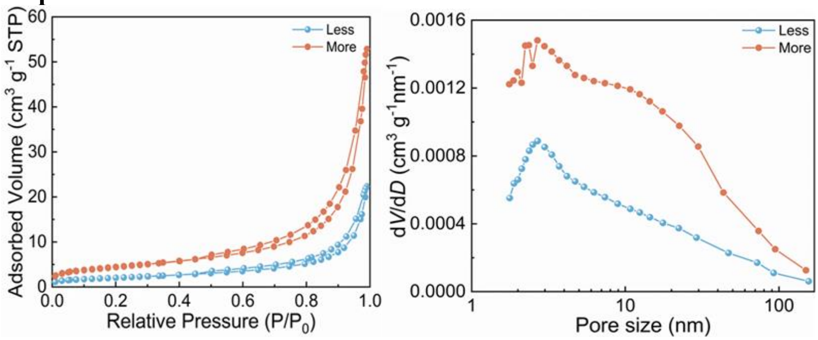


Fig. 7. Comparison of BET and BJH test results of two types of iron ore with different moisture contents

3 Results and Discussion

This paper provides a microscopic analysis method for high moisture iron ore, which is the first analysis method designed in China to study the phenomenon of abnormally high moisture content in the same country's imported ore. Through comparative experiments, the characteristics of high moisture iron ore are analyzed. The characteristics of high moisture iron ore imported from Australia are studied from different angles by DTA method, XRD test, SEM observation, EDS measurement, and BET and BJH methods. Through comparative experimental results, the following conclusions are drawn: [5] (1) The comparative experimental results of the DTA method (see Figure 1) show that both types of iron ore underwent significant weight loss at 522K and 624K, and the preliminary study indicates that the two types of iron ore have convergence in the dehydration process; The main cause of weightlessness is the dehydration of crystal water in iron ore.at the same time, the thermal gravimetric curve analysis shows that the Australian ore with 15% moisture content underwent significant weight loss at 369K (H2O), which helps to determine whether the high moisture iron ore (15% moisture content) is an inherent characteristic of the mineral itself or artificially injected water at room temperature. The main cause of weightlessness is the dehydration of free water in iron ore, because this temperature is the temperature at which free water in iron ore evaporates completely. This characteristic can help to distinguish high water content iron ore (15% water content) is not inherent characteristics of its own minerals, there is a great possibility of external impact.(2) [10]The XRD comparative experimental test results show that the Australian iron ore with a moisture content of 7.5% is mainly composed of Al3Fe5O12.and the Australian iron ore with a moisture content 15% is mainly composed of Fe2O3, Al3Fe5O12, and SiO2 (see Figure 2).and[6] the elemental distribution and proportion relationship shown by the EDS comparative experimental measurement (see Figure 5, Figure 6), the EDS results shown in Table 1 and Table 2, indicates that the Australian iron ore with a moisture content of 7.5% has O element, Al element, Si element, Ti element, Fe element, and The element contents are Fe>O> Si > Al,> Ti. and the Australian iron ore with a moisture content of 15% has O elemen,Al elemen, Si elemen, P elemen,Fe elemen, and The element contents are Fe>O> Si > Al,> P.(3) The SEM comparative experimental test (see Figure 3, Figure 4) shows that the size of the Australian iron ore with a moisture content of 15% (high moisture sample) is obviously smaller than that of the Australian iron ore with a moisture content of 7.6% (low moisture sample). [14] The Australian iron ore with a moisture content of 15% (high moisture sample) shows pore structure, larger pores, more pores, this kind of ore structure is easier to absorb water, thus forming a high water content. At the same time, the BET and BJH comparative test (see Figure 7) shows that the high moisture sample, i.e., the Australian iron ore with a moisture content of 15%, has a larger specific surface area. Preliminary studies indicate that the larger the specific surface area of the iron ore, the smaller the particle size, the easier it is to adsorb moisture.

4 Conclusion

[9]Through experiments from different angles such as DTA method, XRD test, SEM observation, EDS measurement, and BET and BJH methods., a comprehensive analysis of the characteristics of high moisture iron ore from Australia is carried out. Through experiments, We can draw conclusion. [15] (1) The water content of iron ore mainly includes free water and crystal water. The main cause of formation of high and low water content of iron ore can be distinguished by DTA method. Through DTA experiment, We can judge whether the high water content is man-made or natural. We can avoid the invisible loss of tons through the terms of the contract. In order to effectively reduce the moisture content of iron ore. We can reduce the frequency of water spraying in mining and use of closed transport to reduce water content. (2) [7] By BET and BJH methods, the larger the specific surface area of the iron ore, the smaller the particle size, the easier it is to adsorb moisture. We can take physical methods to control the size of iron ore particle size, so as to adjust the water content of iron ore.(3) The analysis of high water content in Australian iron ore can also provide

reference for other countries to control the water content of iron ore.(4)According to the international shipping rules of solid bulk cargo and TML requirements ,The moisture content of iron ore should be reduced below 8% as far as possible to ensure the safety of shipping. we can discharge the sewage during on the voyage to reduce the water content of iron ore.

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