

Study on the Self-Sufficiency of Chromite Resources of China in the Next 15 Years

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Abstract. In this paper, based on the DCF cash flow discount valuation model, and partly using the geological analogy method, we analyse the availability of chromite mineral in China by the provinces and deposits. We eventually calculated the availability data of chromite ore in China at different levels of internal rate of return and different price conditions from 2016 to 2030. With the corresponding results are price-tonnage diagrams, which can dynamically and precisely reveal the trend of chromite mineral availability of China in 2016 to 2030, and make prediction of future domestic demand annually 4 million 500 thousand tons of chromite. In order to promote the sustainable and healthy development of Chinese chromite industry, we propose some pertinent and feasible policies about the development of Chinese chromite resources, such as the technological breakthrough of the recovery rate of Stainless steel, optimization of the distribution of overseas resources supply, elimination or transfer of low end surplus Stainless steel, establishing the strategic reserve system etc

Introduction

Chromium is a kind of silvery and glossy metal. It has the characteristics of hard, wear-resistant, high temperature resistance and corrosion resistance. It is mainly used in the production of stainless steel. It is widely used in shipbuilding, automobile, aerospace, pigment, textile, electroplating, refractory and so on. As a strategic mineral resource, in order to ensure economic security and national defense safety, the United States and the European Union have identified chromite as the key mineral and the concerned raw material [1] in 1970s. China also listed chromate as a strategic mineral in the national mineral resource planning (2016 - 2020) [2].

In 2016, China's Chromite imports reached 10 million 600 thousand tons, domestic output was about 200 thousand tons, and supply and demand were seriously unbalanced. Against this background, it is of great practical significance to study the continuous supply capacity of China's chromite resources. In this paper, the cash flow discounted valuation model is used to study the distribution, structure, total quantity and quality of the available reserves / production of Chinese chrome ore on the basis of field investigation and the types of ore deposits, development and utilization and distribution of administrative areas. In the past 15 years, the changing trend of China chrome ore resources supply capacity under different internal rate of return and different market prices will provide reference for the chromium mine to strengthen the guarantee and keep healthy development.

Theory of Availability Analysis

As the price of the market is uncertain, the mineral reserves and production of a country are not always available, and in a certain price condition, only part of it is available. It is necessary to establish a unified and comparable calculation standard for the mine availability index, to solve the price of mine and the available reserves and production, and to extract the corresponding mineral reserves and production from the total amount of [3]. In this paper, we use the cash flow discount valuation model to analyze the data by using the "geological analogy" method when the data and data are hard to obtain.

Discounted Cash Flow Model

It is an economic evaluation method for the construction of mine investment and the management of production and management through the income approach. It is based on the forecast of cash flow. It fully considers the capacity of the mine construction and the future of the project to create cash flow, so as to estimate its value so as to make the project investment and operation decision. . The evaluation parameters mainly include reserves of resources, recoverable reserves, production capacity, remaining service years of mine, product plan, mining and smelting index, investment in fixed assets, liquidity, sales income, operating cost, sales tax and additional, enterprise income tax and discount rate.

With the help of the cash flow statement, the rate of return on investment is set and the available price is calculated at the break even point, and then the available reserves and production under this condition are obtained. The basic equation is:

$$NPV = \sum_{t=1}^n (CI - CO)_t (1+i)^{-t} \quad (1)$$

Make the net present value equal to 0:

$$\sum_{t=1}^n \{(P \times W) - CO\}_t (1+i)^{-t} = 0 \quad (2)$$

In the model, *NPV* (net present value), *CO* (total cash outflow), *I* (internal rate of return), *W* (production), *t* (evaluation year), *n* (evaluation year) are known quantities, *P* is the solution variable, which can be used for price.

Considering the time value of capital, that is, the minimum investment effect that the industry or department should reach, or the average profit level, and then designs the internal rate of return. In the three cases of *IRR*=0%, *IRR*=8% and *IRR*=12%, it calculates the price for the chromium mine when *NPV* is 0. If the price of the chrome ore market is $P_m > P$ and the mine can be produced normally, the reserves and production of the chromium mining area can be supplied. If the price of the chrome ore market is $P_m < P$, the mine can not be produced normally, the reserves and production of the mining area are not available [4, 5].

Geologic Analogy Method

Not for field investigation or incomplete financial data of various types around the mining area by geological analogy calculation. This method compares the chromium mine with the completed availability evaluation, which has the similar geographical environment and geological characteristics, and estimates that the mine is available [6]. Calculated by the following formula:

$$P_S = P_X \cdot \mu \cdot \theta \cdot \varphi \quad (3)$$

Among them: P_S can be used to evaluate the price of chromium mines; P_X can be used as a reference to the mine chromium mine for price; μ is the price coefficient; θ is the geological characteristic coefficient; φ is the difference factor coefficient. When using this method to evaluate the mining area, the key is to select a reasonable adjustment coefficient, and the principle of control is that the geographical location is similar, the type of ore deposit is similar, the technical conditions of mining and metallurgy are similar, and the conditions of the external infrastructure are similar.

Evaluation of the Availability of the Typical Mining Area of Chromium

According to the specifications for geological exploration of iron, manganese and chromium deposits, only one type of late magmatic deposits has been discovered in China. According to the ultrabasic rock type produced by chromite, the late magmatic chromium deposits can be divided into two types[7,8].By the end of 2016, there were 63 chromium deposits in China, with 11 million 619 thousand and 900 tons of reserves and distributed in 14 provinces such as Tibet and Xinjiang. Among them, 3 medium-sized, 60 small, 3 medium-sized mining areas have 5 million 525 thousand

and 900 tons of reserves and 60 tons of chromite in small mining areas, with 5 million 893 thousand and 600 tons of reserves. Tibet chrome mine reserves 3 million 873 thousand and 300 tons of resources, the first in the country, 2 million 426 thousand and 100 tons in Gansu, 1 million 596 thousand and 300 tons in Inner Mongolia, 782 thousand and 600 tons in Qinghai, and less in other provinces [9,10,11].

A representative mine is selected based on the field investigation data of chromium mine for example. The available prices of typical chromium mines under three different internal rate of return conditions are calculated respectively and their available reserves / production from 2016 to 2030 (table 1~5).

Table 1 Availability evaluation of Luobusha mine, Tibet

Year	Price(yuan/ton)			Rserve ten thousand tons	Production ten thousand tons
	IRR=0%	IRR=8%	IRR=12%		
2016	1200	1312	1440	64	4.5
2020	1200	1312	1440	44	4.5
2025	1200	1312	1440	19	4.5
2030	/	/	/	0	4.5

Table 2 Availability evaluation of Luobusha mine, Tibet

Year	Price(yuan/ton)			Rserve ten thousand tons	Production ten thousand tons
	IRR=0%	IRR=8%	IRR=12%		
2016	1240	1365	1452	94	4.7
2020	1240	1365	1452	73	4.7
2025	1240	1365	1452	46	4.7
2030	1240	1365	1452	20	4.7

Table 3 Availability evaluation of Saertuohai mine, Xinjiang

Year	Price(yuan/ton)			Rserve ten thousand tons	Production ten thousand tons
	IRR=0%	IRR=8%	IRR=12%		
2016	1370	1450	1566	31	2
2020	232	253	260	22	2
2025	232	253	260	10	2
2030	/	/	/	0	2

Table 4 Availability evaluation of Kedanshan mine, Inner Mongolia

Year	Price(yuan/ton)			Rserve ten thousand tons	Production ten thousand tons
	IRR=0%	IRR=8%	IRR=12%		
2016	1305	1385	1455	37	2
2020	1305	1385	1455	26	2
2025	1305	1385	1455	15	2
2030	1305	1385	1455	3	2

Table 5 Availability evaluation of Subei mine, Gansu

Year	Price(yuan/ton)			Rservices ten thousand tons	Production ten thousand tons
	IRR=0%	IRR=8%	IRR=12%		
2016	1250	1310	1385	58	3
2020	1250	1310	1385	44	3
2025	1250	1310	1385	30	3
2030	1250	1310	1385	16	3

Analysis of the Availability of Chromium Ore in China

This method is used to evaluate the availability of 63 types of chrome ore areas in China and to analyze the supply capacity of chrome ore to the economic and social development by combining other factors. According to the survey results and the market market in recent years, the cost and price of Chinese chrome ore production is generally above 1200 yuan / ton, that is, the mine enterprises using internal accounting price are also less than the case of this price. When the price is higher than 1800 yuan / ton, the vast majority of the producers will be profitable. Therefore, the price interval is divided into 3 gradients, followed by 1200 yuan / ton, 1500 yuan / ton, and 1800 yuan / ton.

Evaluation of the Available Reserves and Production of Chromium Ore in China

Table 6~7 shows that in maintaining 12% of the internal rate of return, in fact, the level of profitability has been higher, to meet the decline in the number of such high yield enterprises. Under this condition, the reserves of chromium ore in China will reach 4 million 680 thousand tons in the next 15 years, and production will increase and then decrease, up to 240 thousand tons.

Table 6 Available chromite reserves of China from 2016 to 2030 (IRR=12%)

Price (yuan/ton)	Reserves(Ten thousand tons)			
	2016	2020	2025	2030
1800	468	327	216	137
1500	374	262	173	109
1200	300	209	138	88

Table 7 Available chromite production of China from 2016 to 2030 (IRR=12%)

Price (yuan/ton)	Production(Ten thousand tons)			
	2016	2020	2025	2030
1800	16	24	19	14
1500	13	20	15	12
1200	10	16	12	9

In table 8~9, when we choose 8% of the internal rate of return, the level of corporate profitability is moderate. At this time, China will have a maximum reserves of 6 million 500 thousand tons of chrome ore in the next 15 years, and it will float between 20-34 tons.

Table 8 Available chromite reserves of China from 2016 to 2030 (IRR=8%)

Price (yuan/ton)	Reserves(Ten thousand tons)			
	2016	2020	2025	2030
1800	650	454	300	190
1500	520	360	240	150
1200	416	291	192	122

Table 9 Available chromite reserves of China from 2016 to 2030 (IRR=8%)

Price (yuan/ton)	Production(Ten thousand tons)			
	2016	2020	2025	2030
1800	22	34	26	20
1500	18	27	21	16
1200	14	22	17	13

In table 10~ 11, we choose the extreme situation where no profit is guaranteed, that is, 0 yield. Under this condition, the reserves of chrome ore will reach 7 million 400 thousand tons in the next 15 years, and the production can reach 390 thousand tons. The above table shows that the availability of chromium ore in China is closely related to the market price, and the available reserves / production increases obviously when the price is high.

Table 10 Available chromite production of China from 2016 to 2030 (IRR=0%)

Price (yuan/ton)	Reserves(Ten thousand tons)			
	2016	2020	2025	2030
1800	740	518	342	217
1500	593	414	274	173
1200	474	331	219	139

Table 11 Available chromite production of China from 2016 to 2030 (IRR=0%)

Price (yuan/ton)	Production(Ten thousand tons)			
	2016	2020	2025	2030
1800	25	39	30	23
1500	20	31	24	18
1200	16	25	19	15

China Chromite Available Reserves and Production Tonnage Diagram

(1) Arbitrarily selected price conditions correspond to the clear response of the available reserves under different rates of return on the abscissa.

1) Under the three internal rate of return of IRR=12%, 8% and 0%, the maximum reserves of chrome ore in China in 2020 were 3 million 270 thousand tons, 4 million 540 thousand tons and 5 million 180 thousand tons (Figure 1).

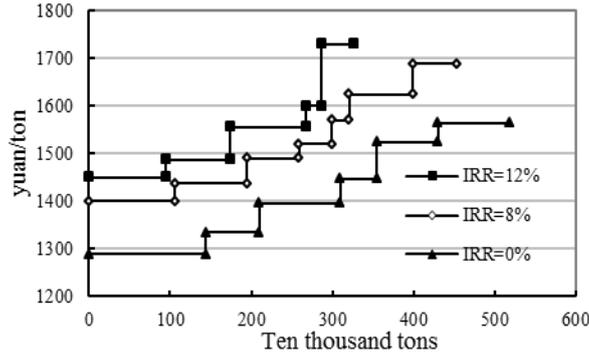


Fig. 1 Available chromite reserves-tonnage graph, 2020

2) Under the three internal rate of return of IRR=12%, 8% and 0%, the maximum reserves of chrome ore in China in 2030 were 1 million 370 thousand tons, 1 million 900 thousand tons and 2 million 170 thousand tons (Figure 2).

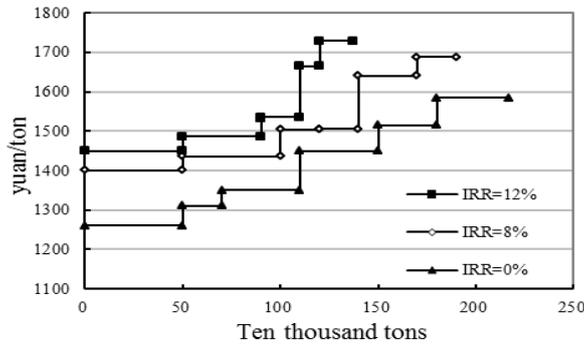


Fig. 2 Available chromite reserves-tonnage graph, 2030

3) under the three internal rate of return of IRR=12%, 8% and 0%, the maximum production of chrome ore in China in 2020 was 240 thousand tons, 340 thousand tons and 390 thousand tons (Figure 3).

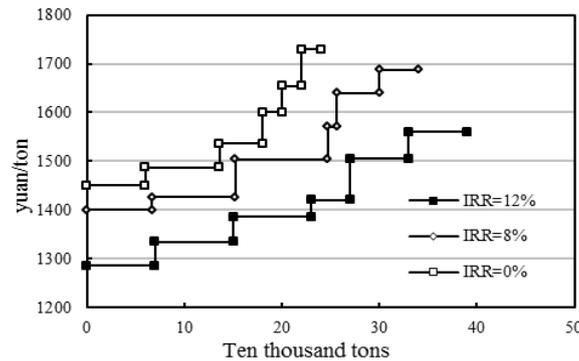


Fig. 3 Available chromite production-tonnage graph, 2020

4) Under the three internal rate of return of IRR=12%, 8% and 0%, the maximum production of chrome ore in China in 2030 was 140 thousand tons, 3 million 200 thousand tons and 230 thousand tons (Figure 4).

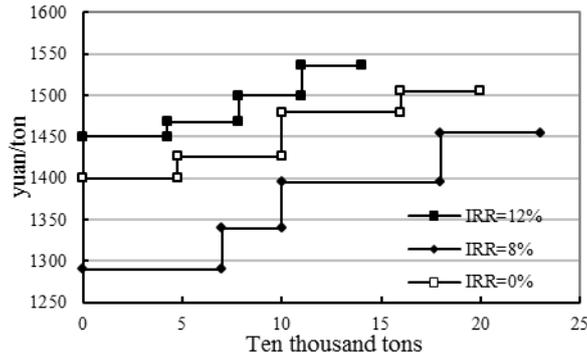


Fig. 4 Available chromite production-tonnage graph, 2030

(2) under the regular level of IRR=8% in Figure 5 and Figure 6, under the conventional level of internal rate of return, 1800 yuan / ton, 1500 yuan / ton, 1200 yuan / ton are calculated, and the annual production and available reserves per year for Chinese chrome ore are available for each year from 2016 to 2030, and the trend of change is summarized.

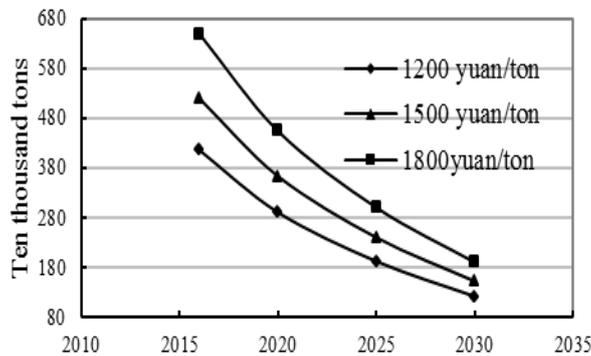


Fig. 5 Available bauxite reserves-prices graph of China from 2016 to 2030

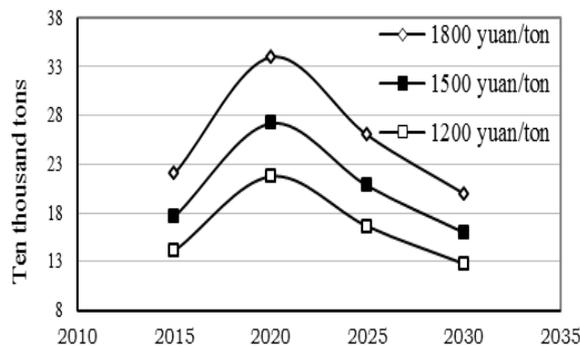


Fig. 6 Available bauxite production-prices graph of China from 2016 to 2030

From 2016 to 2030, with the increase of price, the reserves and production of chromite in China will increase significant, and the higher the price, the greater the supply. A more significant feature is that the higher the price, the greater the amount of available reserves and available production, because high prices can allow many low quality chrome mineral resources in China to enter the market.

Conclusions

In the next 15 years, in the standard situation, that is, IRR=8%, the price is 1500 yuan / ton, the reserves of Chinese chrome ore resources can reach 5 million 200 thousand tons in theory, and the

production is only 300 thousand tons per year, mainly in the western provinces of Tibet, Xinjiang, Gansu and so on. Chen Qishen and others predicted that the annual average annual consumption of chrome ore in China will reach 16 million 900 thousand tons [12] in 2020, and the consumption of Chinese chrome ore will reach more than 13 million tons [13] before and after the prediction of Zhang Wei and so on. The future reserves / production of domestic chrome ore can not meet the demand of domestic chrome ore. And the production of chromium ore in China is not only the problem of total amount, but also the supply structure problem, which is reflected in the shortage of high quality ore supply, and the natural resource characteristics make the effective supply of chrome ore increase slowly.

Suggestions

1) Increase exploration and make rational use of domestic chromium resources. On the one hand, finding new producing area of chromite, exploring new type of chromite, strengthening the outside and deep prospecting of known chromite, using new technology and new method for indirect prospecting, further research on metallogenic theory, providing guidance for prospecting and evaluation of metallogenic potential are effective measures. On the other hand, Tibet robera is a high quality metallurgical grade chromium ore, and other provinces and regions are chemical grade and refractory grade chrome ore, which should be well protected and used good quality chrome ore of Roberto chrome [14].

2) The import of chrome ore is in high order. We should make full use of the resources of chromium ore in South Africa, Turkey, Zimbabwe and other places. By optimizing the distribution of overseas resources supply, we should make up the gap in the demand for high quality chrome ore in our country and disperse the resource risk of a single country.

3) In view of the current situation of China facing a severe trade war, we should establish a reserve mechanism of chromium resources to ensure its sustained and stable supply. According to the current consumption of chromium resources in China, the scale of the storage is 2 million tons, which can effectively guarantee the domestic demand of for 90 days [15].

4) To establish a complete two recycling system, to strengthen the recycling of chromium containing waste resources and to study the fusion technology of stainless steel waste can effectively alleviate the dependence on overseas resources. Starting with the recovery policy and recovery system, we should establish efficient recycling channels and make perfect subsidies and tax policies to improve the enthusiasm of enterprises to recover waste and waste resources.

5) Stainless steel is the most important part of the consumption of chromium ores in China. In the long run, we should promote the transformation and upgrading of the whole steel industry, phase out or transfer the low end, surplus stainless steel production capacity, and fundamentally improve the supply and demand situation of Chinese chrome ore [16].

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