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Research on Availability of Refractory Aluminium Resources

难利用含铝资源可利用性研究

（英文版）

Zhao Hengqin 赵恒勤 著
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Abstract

China, the largest aluminium producer, is seriously lacking of reserves at the present and in the future. However, there are huge amount of sub-economic aluminium resources (high iron diasporic, low A/S and high iron gibbsite and high sulfur diasporic bauxite), and potassic sandy shale suitable for the extraction of aluminium and the production of potassium and silicon fertilizers if proper metallurgical processes are developed.

This study aims to investigate the sub-economic aluminium resources through investigation and identify the right technologies through laboratory tests for metal extraction and ultilization of the by-products of K-feldspar sandy shale.

The investigation of the sub-economic aluminium resources includes the field and site visits and the data collection and collation. A series of laboratory scale tests were carried out for different types of bauxite and potassic sandy shale, which includes the initial try tests and the formal laboratory experiments for the optimization of the processes and procedures, and crop planting tests for use of potassium and silicon fertilizers.

The successful laboratory tests (technologies) in this study were optimized and proved to be effective. The results showed: 1) Medium temperature metallization roasting and then magnetic separation, and gas reduction metallization roasting and then magnetic separation are effective for processing the high iron diasporic bauxite; 2) Dry magnetic separation, wet magnetic separation and medium temperature magnetization roasting and then magnetic separation are not effective for processing the high iron diasporic bauxite; 3) Digestion at atmospheric conditions and high caustic alkali concentration is effective for processing the low A/S and high iron gibbsite bauxite;

4) Desulfurization flotation and desulfurization with barium aluminate are both effective for processing the high sulfur bauxite. However, each of these methods has their own advantages and disadvantages and must be evaluated; 5) The soda-lime sintering process is suitable for processing the Linzhou potassic sandy shale. The aluminium and potassium are extracted and the silicon residues can be used for silicon fertilizer.

The results of this study is favour to solve the problem of aluminium reserve shortage. They also develop a new way for integrated ultilisation of other aluminium resources including potassic sandy shale.

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Abbreviations and Explanation

A/S: Alumina to silica ratio: The mass ratio of Al_2O_3 to SiO_2 in the bauxite;

Alkalinity: The molar ratio of the sum of potassium oxide and sodium oxide to alumina;

Caustic alkali concentration: The concentration of sodium oxide combined as sodium hydroxide;

K_2O_K: Caustic potash. It means potash oxide combined to form potash hydroxide;

LOI: Loss of ignition. It is defined as the mass losses percent by heating the samples at 1 000℃ for 45 minutes;

MFe: Magnetic Fe content;

min: Minute;

NA: Not Available;

Na_2O_C: Carbonate alkali. It means sodium oxide combined to form sodium carbonate;

Na_2O_K: Caustic alkali. This is sodium oxide combined to form sodium hydroxide;

Na_2O_S: Sulphate alkali. It means sodium oxide combined to form sodium sulphate;

Reserve base: That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is in place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those are currently sub-economic (sub-economic resources). The term "geologic reserve" has been applied by others generally on the reserve-base category, but it also may include the inferred-reserve-base category; it is not a part of this classification system.

Reserve: That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves don't need signify that extraction facilities are in place and operative. Reserves only include recoverable materials; thus, terms such as ' extractable reserves ' and ' recoverable reserves ' are redundant and are not a part of this classification system.

Resource: A concentration of naturally occurring solid (or liquid, or gaseous) materials in or on the Earth's crust in such a form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

SEM: Scanning electron microscopy;

T: Reaction temperature;

TFe: Total Fe content;

XRD: X-ray diffraction;

α_k: Caustic ratio. The mole ratio of sodium oxide combined to form sodium hydroxide to alumina;

η_B: The ratio of barium aluminate dosage to the theoretical barium aluminate dosage;

Calcia-silica ratio: the mole ratio of calcia to silica;

τ: Reaction time;

RMB: The abbreviation of the Ren Min Bi, China's currency.

Contents

1 Introduction

1.1 Status and investigation of aluminium resources, alumina and aluminium

Aluminium is one of the most abundant metallic elements in the earth's crust (over 7% by weight) (normally expressed in % in this document) and the third most abundant of all elements. However, because of its chemical nature, it is mostly found in its oxidized form (approximately 250 different minerals) and almost never occurs in the elemental state. The most prominent groups of aluminium bearing minerals are silicates. Its hydroxides ($Al(OH)_3$) represent the most important source of aluminium. The hydroxides and bauxite minerals gibbsite (γ-$Al(OH)_3$), boehmite (γ-AlOOH) and diaspore (α-AlOOH) are the base raw materials for primary aluminium production. They form by weathering feldspar rich low iron and silica source rocks such as granite and rhyolite under the tropical climatic conditions.

Aluminium is normally produced from bauxite, which ore containing aluminium oxide (Al_2O_3) and being commonly called alumina. Alumina is first extracted from bauxite through a refining process and then converted to aluminium metal through an electricity-intensive smelting process.

1.1.1 Status of aluminium resources, alumina and aluminium in the world

The world's largest bauxite deposits (reserves) lies in Guinea, Australia, Brazil and Jamaica (World Bureau of Metal Statistics, 2008). There are approximately 55 to 75 billion tons of bauxite in the world, of which 33% is found in Africa, 24% in the Oceania, 22% in the Caribbean and South America, 15% in Asia and the remaining

6% is located elsewhere (Table 1 – 1).

The world bauxite production trends, reserves and reserve base by country are shown in Table 1 – 2, in which Australia is the number one in terms of the bauxite reserves and reserve base. While the world output of bauxite is shown in Table 1 – 3. Table 1 – 4 shows the world output of alumina and the world output of primary aluminium is shown in Table 1 – 5.

Table 1 – 1 World bauxite reserves/%
(Bray, 2009)

Area	South America and the Caribbean	Africa	Asia	Oceania	Elsewhere	Total
Reserves	22	33	15	24	6	100

Table 1 – 2 World bauxite mine production, reserves and reserve base by country/kt
(Bray, 2009)

Country	Mine production		Reserves	Reserve base
	2007	2008		
Australia	62 400	63 000	5 800 000	7 900 000
Brazil	24 800	25 000	1 900 000	2 500 000
China	30 000	32 000	700 000	2 300 000
Greece	2 220	2 200	600 000	650 000
Guinea	18 000	18 000	7 400 000	8 600 000
Guyana	1 600	1 600	700 000	900 000
India	19 200	20 000	770 000	1 400 000
Jamaica	14 600	15 000	2 000 000	2 500 000
Kazakhstan	4 800	4 800	360 000	450 000
Russia	6 400	6 400	200 000	250 000
Suriname	4 900	4 500	580 000	600 000
Venezuela	5 900	5 900	320 000	350 000
Vietnam	30	30	2 100 000	5 400 000
United States	NA	NA	20 000	40 000
Other country	7 150	6 800	3 200 000	3 800 000
World total (rounded)	202 000	205 000	27 000 000	38 000 000