REFRACTORY RAW MATERIAL POTENTIALS IN IRAN

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ABSTRACT

This paper gives the latest information on refractory raw material reserves. The rapidly increasing growth of steel and cement production as the most important refractory consuming industries in Iran, presents the outstanding refractory demand. Despite of the existence of suitable refractory raw material potentials in the country, the considerable amounts of these materials are still imported. Furthermore, the Iranian refractory industry requires to special refractory raw materials for the modern refractory formulation design that cannot be locally produced. It appears that the local suppliers must be striving to offer raw materials with high quality, constant level of quality and good cost to benefit ratios. Also, foreign investments and technology approach from developed countries help to introduce and improve production processes.

INTRODUCTION

During the last years, the rapidly growing and development of Iranian industries, especially steel, cement, nonferrous alloys, petrochemical and ceramics, has resulted in increased demand for refractory materials. The growing demand to give rise to increase production of domestic refractory manufacturers, and therefore the consumption of refractory raw materials is growing every year. Figure 1 gives a rough histogram of production, consumption and shortage of the refractory grade raw materials in 2003. On the other hand, the existence of major refractory producer such as China in the international markets and their influence in the Iranian refractory market; bring to mind this question whether the domestic refractory raw material potentials can provide the local demand both quantitative and qualitative aspects.

China is the dominant supplier of imports for refractory raw materials, and has been a low cost source of refractory raw materials. In addition to the low price, Chinese materials have an appropriate and consistent quality [1].

Unfortunately, little information on Iranian refractory raw material reserves and their qualities has been available. In 1993,"The Refractory Comprehensive Report" was published in which the information on refractory raw materials and refractory production, consumption, import and export in Iran were given [2]. Since then, the refractory raw material reserves in Iran have enhanced both from quantity and production capability point of view. Table 1 summarizes the proved reserve and exploitation rate of the mines that supplied the refractory raw material consumers in year 2003 [3]. At the present, in spite of this growing, the refractory industry of Iran requires high quality raw materials with the confident reserves. This report will survey the raw materials situation in the country. The data in this paper has been obtained from individual companies and Iranian Ministry of Industries and Mines reports.

Table 1- Situation of Refractory Raw Material Supplying Mines in Iran (year 2003)

Ore Type	Number of Mines				Exploitation Rate (t)	Proved Reserve (1000t)
	State	Cooperative	Private	Total		
Magnesite	0	4	23	27	128,565	3,542
Dolomite	3	5	19	27	439,503	91,181
Chromite	2	3	34	39	512,640	16,371
Bauxite	1	2	6	9	57,254	25,030
Fireclay	5	12	23	40	410,997	108,586
Silica	6	16	90	112	1,878,867	888,559

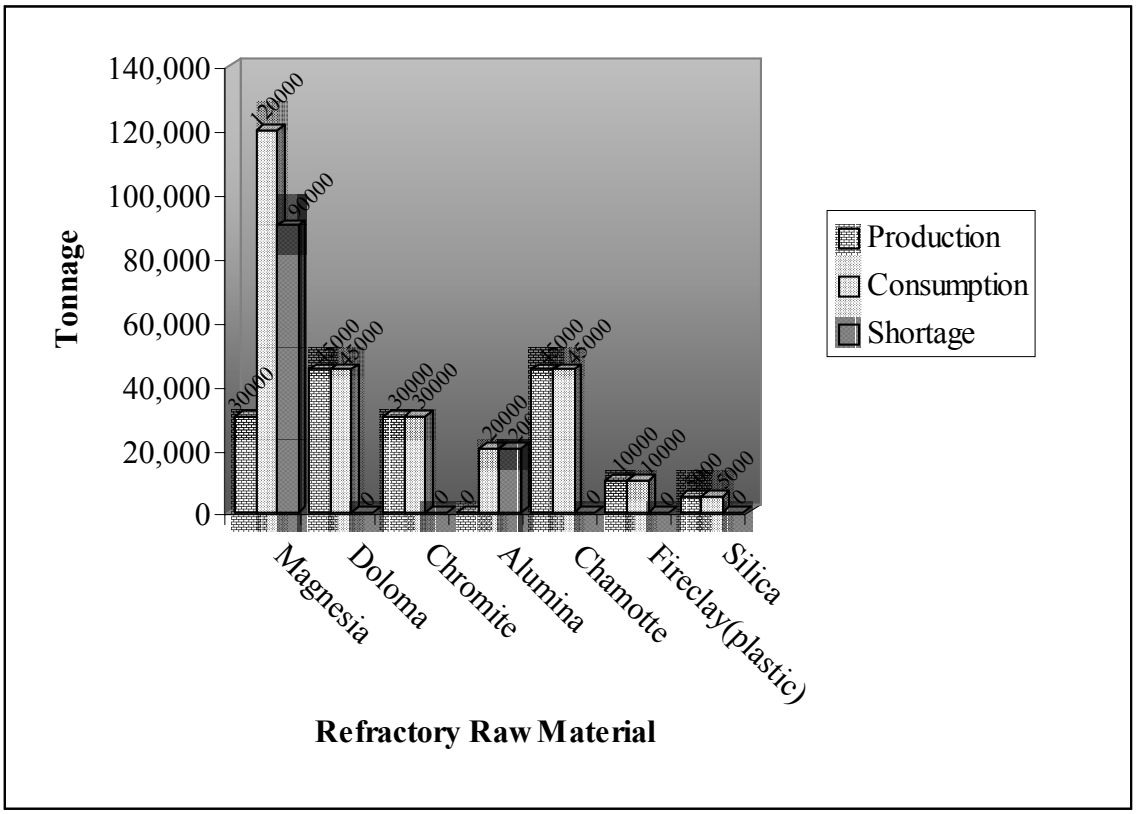

Fig.1- Refractory Grade Raw Materials Situation in Iran (Year 2003)

MAGNESIA

Sources of refractory-grade magnesia used in the manufacture of basic refractories may be broadly categorized as natural or synthetic. Natural magnesite or magnesium carbonate is a mineral composed of 47.8% MgO and 52.2% CO_2 in pure form. Commercial deposits of natural magnesite are found in Khorasan and Sistan-Blouchestan provinces. Proper physical and chemical characteristics of premium grade natural magnesites are necessary for specific refractories. Overall, refractory-grade dead-burned magnesites are categorized by source, chemistry, including type, amount and location of accessory silicates (defined by placement of lime and silica accessory oxides), crystallite size, and distribution of periclase and accessory silicates. The only Iranian magnesia producer is located in Khorasan province with production capacity of 30,000 tpa. Dead-burned magnesia is produced in various grades from 88% to 96% MgO and grain size 0-25 mm according to application. These amounts of refractory magnesia are achieved from domestic natural magnesite mines that produced 128,565 ton magnesite ores in 2003. The total reserves of Iranian natural magnesite deposits are estimated 3,542,000 ton [3], which mainly contain low grade magnesite ores. At the present, Demand for refractory magnesia in Iran, particularly high grade types, is about 120,000 tpa that will continue to be directly affected by the health of the Iranian steel industry. Therefore, the domestic dead-burned magnesia production, both of quantity and quality aspects, cannot supply local consumers.

DOLOMITE

Dolomite is a double carbonate of calcium and magnesium. Commercial dolomite compositions may vary considerably from one region to another. Although common throughout the earth's crust, dolomites having proper chemical, mineralogical and physical properties for a refractory raw material are relatively rare. Mined, crude dolomite, properly upgraded if necessary, must be fired at relatively high temperatures to achieve a dense, relatively inert aggregate known as refractory grade, dead-burned dolomite (Doloma). Properly produced dolomite has excellent refractory properties. Dolomite types include iron-enriched grades, designed to possess lower melting characteristics, as well as higher purity types, used for refractory brick making or monolithics.

The geological characteristics of Iran caused that the natural dolomite deposits have been abundant, so that the proved reserves of deposits have estimated up to 91,181,000 ton in 2003[3]. The indicated reserves have reported approximately 1,173,190,000 ton in 1993[2]. Unfortunately, the resources for high grade classes of doloma are still missing [4]. Nowadays domestic doloma production grows up to 45,000 ton, which is coincided with demand for this raw material.

CHROME ORES

Chrome ores, or chromites, often called chrome-enriched spinels, are naturally occurring members of the spinel mineral group. These materials are all characterized by relatively high melting points, good temperature stability (particularly in thermal union with magnesite) and moderate thermal expansion characteristics. Control, placement and quantity of gangue minerals are as important to finished refractory properties as the basic chemical composition of the individual ore. Ores are often upgraded by mechanical separation techniques to minimize impurities. Thus, chrome concentrates with low gangue impurities are often the article of commerce used in refractories. Critical aspects of chrome ore are final size and chemistry. Size related to the natural textural features of the ore. Hardness of the ore, impacts the ultimate size of the commercial material. Iranian ores may be massive and tend to produce more coarse materials.

The chromite deposits of Iran were occurred in the ophiolite belts, which mostly located on south and east of the country. Although, the ores are alumina-bearing types that are suitable for refractory applications, but there are not any sources for high grade classes. This problem mainly has resulted from high silica contents in the ores. In 2003, the Iranian chromite mines output was about 512,640 ton, and the proved reserves were estimated up to 16,371,000 ton [3]. This amount of production supplied the most of the local demand.

OLIVINE

Olivine is a naturally occurring raw material containing a mixture of the minerals forsterite and fayalite in solid solution. Because of the absence of any volatiles and good density and stability characteristics, olivine requires no pre-calcining prior to use. Most refractory olivines are closer to forsterite composition. Iron oxide tends to lower the refractoriness, but aids sintering. Typical olivines for the refractory industry contain about 45% to 50% MgO, 40% to 45%SiO2, and 6% to 10% FeO. This raw material is still relatively inexpensive source of basic aggregate, and is surprisingly stable for certain product applications where high refractoriness is not a requirement.

Forsteritic olivine occurrences were found abundantly in the ophiolite belts of Iran, especially in southern parts of the country. These deposits mostly contain large scale reserves with proper ores for refractory uses, and require to detailed studies.

ALUMINA

Alumina represents a broad group of materials widely used in the refractory industry. In the modern refractory concept, alumina is the primary ingredient for a significant portion of the products used in high temperature industrial applications. Alumina- based refractories are crucial components in nearly all high temperature metallurgical, cement, ceramic, glass and petrochemical manufacturing processes in modern industry. In general, the ability of an alumina-based material to resist high temperatures increases with increasing alumina content [1]. Aluminas are classified in two device; synthetically produced, known in the trade as calcined, tabular, or fused that are almost entirely purchased from abroad; and naturally occurring alumina silicate sources, such as bauxites, diasporas, bauxitic kaolins, andalusite, sillimanite, and kyanite, which their deposits exist on different locations in Iran.

BAUXITE

Bauxite in the crude state is a naturally occurring group of minerals composed primarily of gibbsite, diaspore, or boehmite, and various types of accessory clays. Ratio and type of aluminous minerals in bauxites vary from one geological setting to another.

Refractory grade calcined bauxites are a specific form. Important features of these bauxites are maximum alumina values, maximum bulk density, and minimum impurities such as iron oxide, titania, alkalis and alkaline earths. A dependable size range for run-of-kiln commercial material is also important, as is relative hardness. The final market acceptance of bauxite for refractory use is contingent upon the physical and chemical qualities of the commercial end product into which it is to be included or combined. A limited number of naturally occurring bauxites have been found to meet the stringent physical and chemical specifications expected of refractory grade bauxite, particularly within the very high temperature fields encountered in most industrial applications. The highest quality materials have historically been supplied from mines in Guyana. As a result, because of its high quality, the refractory A-grade super calcined product from Guyana has frequently been used as a reference standard for comparison with calcined refractory bauxites from alternative sources of supply [1].

In Iran, there are several bauxite deposits with total proved reserves about 25,030,000 ton, which produced approximately 57,254 ton bauxite ores in 2003 [3]. Unfortunately, the green Iranian bauxite ores contain more iron oxide, titania, alkalis and alkaline earths than the refractory-grade bauxites, such as Guyana, South America and China bauxites. Furthermore, the alumina products of the only local manufacturing plant (Jajarm plant) were not yet applied by refractory industries. Nowadays, all of the mined bauxite ores, as flint clay, use for chamotte production, which is estimated about 45,000 tpa, and supplied the local demand.

SILLIMANITE GROUP

Andalusite, sillimanite and kyanite comprise the water-free, natural aluminum silicate varieties of minerals known as the sillimanite group. Andalusite and kyanite are the more common commercial materials. These minerals are normally about 60% alumina, with the balance composed primarily of silica with minor iron oxide and titania impurities. Andalusite and sillimanite have several important characteristics. When heated at high temperatures, the refractory mineral mullite is formed. This mineral, a key component of many high-alumina materials, when combined with the relatively coarse crystal structure of the andalusite and sillimanite starting-materials, affords very good high temperature creep resistance in formed refractory shapes. Pre-calcining is not necessary due to the relatively low volume change in high temperature conversion to mullite. Natural grain size, chemistry and other mineralogical accessories differ from one district to another, and care must be exercised in selection of the proper material to suit the producer's requirements. Coarse crystal size, low iron oxide and low alkalis are all relevant to the selection process.

There are several andalusite-sillimanite resources in Iran. The main resources are located on the Hamadan, Khorasan, Sistan-Bluchestan, Kerman and Yazd provinces. It is necessary to carry out detailed exploration and complementary beneficiation studies on these deposits. At the present, only one of the andalusite deposits is active in Hamadan province. This deposit has probable reserve about 60 Mt with 10% grade, which produced approximately 3,000 ton andalusite concentrate in 2003.

REFRACTORY CLAYS

Although clays were among the first raw materials used to make refractories, their usage has declined as demands placed on modern refractories have necessitated better performing materials to replace them. Nevertheless, clays are still important materials in the industry. The clays range from plastic to flint, each selected for specific chemistry, physical and refractory characteristics. Shrinkage, P.C.E., alkali levels, fired properties, iron oxide and titania impurity levels, all are important technical features of fireclays and must be controlled to assure product uniformity.

There are many fireclay and ball clay deposits in the country, which their mined ores have been used in local production of firebrick, grogs, refractory mortar and particularly in ceramics. The measured reserves were estimated up to 108,586,000 ton, and actual output of the mines was 410,997 ton in 2003, which mostly are consumed in ceramic industries. It seems that, the consumption of the raw materials in refractory will decrease, while the demand for them by the ceramics industries, particularly porcelain tiles and sanitary ware sectors, to be affected by the rapidly growth of the industries will increase in future.

SILICA-NATURAL

Natural silica occurs primarily as the mineral quartz. Silica raw materials used in the manufacture of conventional silica refractories must contain high silica and low impurities, particularly alumina and alkalis, which can act as fluxes during firing of the refractory and reduce overall refractoriness of the end-product. High quality silica refractories, even though markets have subsided for the more conventional types over the years, exhibit excellent refractoriness when properly used.

The total proved reserves of silica deposits are about 888,559,000 ton, which produced 1,878,867 ton silica ores in 2003. It looks that, only a little amount of them, approximately 5,000 ton, consumed in local refractory industry.

In addition to the raw materials mentioned above, the Iranian refractory industry require to a significant amount of zirconia, graphite, fused alumina, tabular alumina, refractory-grade calcined bauxite, calcium aluminate and other special materials that may not be produced locally and must be entirely imported.

CONCLUSION

The results of this study indicate that the Iranian refractory raw materials potentials may not completely supply the local demand both from quantity and quality point of view. Therefore, we observed the considerable imports of foreign refractory raw materials in recent years. There are suitable potentials in the country, which must be studied. Furthermore, it must be noted that local refractory raw material suppliers must be striving to offer raw materials with high quality, constant level of quality and good cost to benefit ratios. The suppliers with care of mining methods and through selection, beneficiation and blending, may to produce raw materials of uniform quality and then to meet specific standards. Also, foreign investments and technology approach from developed countries have the key roles to introduce and improve quality standards, productivity and consistency of supply for Iranian raw material producers.

ACKNOWLEDGMENT

The author wishes to thank Mr. S.R.Sajjadian, Mr. H.R.Masoumi and Mr.A.R.Bagheri for their active participations in the data collection of this article. Also I am grateful to Mr. Houshmand and Mrs. Zekri from Ministry of Industries and Mines for providing the necessary statistics.

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