

Property File

Mr. Brussilof

BAYMAG - FUSED MGO FOR STEELMAKING REFRACTORIES

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ABSTRACT

An exceptionally pure natural magnesite is the base for Baymag's refractory grade fused magnesia. The magnesite deposit, situated in the Canadian Rocky Mountains in British Columbia was discovered in 1966. Baymag started in 1982 mining and producing calcined magnesium oxide. In 1984 a 3,000 m.t.p.y. Higgins type fusing unit was installed to produce fused magnesia solely for the application in high quality steelmaking refractory products, - magnesia-carbon bricks. Today Baymag owns the newest and most advanced magnesite fusing plant in the western hemisphere with an initial capacity of 14,000 m.t.p.y.

INTRODUCTION

Fused magnesia is an industrial mineral which until recently was quite unknown in the refractory industry. While it has been produced for several decades and applied as so called electrical grade fused MgO, mainly in heating elements¹, it took until the late 1970's before changes in steelmaking technology, driven by the Japanese steel industry, put fused magnesia on the list of refractory raw materials.

Baymag², the most recent addition to the North American magnesium oxide producers, this year, opened a brand new highly automated MgO fusing plant with an initial capacity of 14,000 m.t.p.y.

Before getting into the specifics of fused magnesia, a short introduction of the company, its history, the product range and the magnesium oxide market in general.

COMPANY HISTORY AND FACTS

Baymag is a Canadian company based in Calgary, Alberta with two

production plants located at Exshaw, Alberta and a magnesite deposit situated in the heart of the Rocky Mountains close to Radium Hot Springs in British Columbia. Baymag is German owned and has commercially produced calcined magnesium oxide since 1982 and fused MgO since 1984. In 1966 G.B. Leech of the Geological Survey Branch of Canada discovered what is known today as one of the purest coarse crystalline magnesite deposits in the world during a regular field mapping trip in the Kootenay region of southeastern British Columbia. A claim staking rush followed shortly thereafter and in 1971 Baymag was founded. Large scale diamond core drilling was initiated the same year.

The exploration of the Baymag Mount Brussilof magnesite deposit went through various stages from 1971-1974 resulting in 59 core drill holes totalling 5,255m in length. Based on the analytical data collected from 1,160 core samples, total reserves exceeding 50 million m.t. of high grade, low iron magnesite ore have been proven. Additional substantial core drilling during 1987 (34 holes, 2,700m) did add another 10 million m.t. of high grade reserves. The exploration and ore reserve calculation thus far only covers an area of three claims out of 233 held. This means that the total potential of this reserve is not yet known.

Figure 1 shows a birds eye view of the Baymag open pit mining operation which is run year round and currently produces 180-200,000 m.t. of high purity magnesite of an average composition as shown in Table 1. Figure 2 shows a section of a typical 6m bench of solid magnesite rock. The coarse crystalline nature of the rock is shown in Figure 3. Individual magnesite crystals can reach sizes of up to several centimeters.

TABLE 1: AVERAGE COMPOSITION OF BAYMAG HIGH PURITY
MAGNESITE ORE; LOI FREE, WT%

MgO	97.2
CaO	1.8
SiO ₂	0.2
Fe ₂ O ₃	0.6
Al ₂ O ₃	0.2

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The layout of the mining operation and production sequence are extremely simple due to the purity of the magnesite. Except for a selective mining procedure which is controlled by a rigid quality control program through a computer based mine planning system none of the common ore beneficiation techniques are necessary.

After blasting, the ore is primary crushed and screened to a size of 1 by 15 cm before being stockpiled. The so-called ore fines are screened out and discarded to avoid any possible contamination from clay filled cracks and roadways.

After stockpiling, the primary crushed ore is hauled to the plant at Exshaw which is shown in Figure 4. The heart of the operation is a 3 x 100m natural gas fired rotary kiln with satellite coolers by F. L. Smidth. The incoming primary crushed ore is secondary crushed and then fed to the calcining kiln. Depending on the grade produced, burning zone temperatures reach from 850 to 1,350°C. After calcining, the product is screened to different sizes and, if required, ground to various levels of fineness.

One interesting phenomenon about Baymag magnesite is the decrepitation² that occurs with calcination. The grain destruction at elevated temperatures is not easily explained, but is a major factor in the burning technology. The destruction works to Baymag's advantage, because the most common contaminants - calcite and dolomite - do not show this behaviour; therefore, beneficiation by selective screening can be used. This phenomenon is not unique to Baymag magnesite, but it is restricted to coarse crystalline magnesite and has not been observed in the crypto-crystalline type.

The various uses of so-called calcined magnesia are briefly explained in the next section of this paper. One of the major ones though is to act as a raw material for the fusing operation.

Still in the Exshaw area, about 4 Km west of the calcining operation lies the site of Baymag's new fusing plant as shown in Figure 5. This plant with an initial capacity of 14,000 m.t.p.y. which can be upgraded to 28,000 m.t.p.y. is a combination of well proven so-called Higgins³ type fusing technology and fully computerized and highly automated material

handling/processing equipment.

As stated before, the fusing plant is fed with high purity specially burnt MgO from its own calcining operation. This calcined MgO is automatically fed to one of two identical electric arc fusing furnaces of 7,000 m.t.p.y. capacity each. The Higgins process is a batch type process where so-called ingots of fused magnesia are produced within a steel shell as shown in Figure 6. This shell is insulated from the melt by its own feed material, magnesium oxide.

After one melt is finished, the ingot is cooled in the shell, then by an automatic transfer car system, positioned into a fully enclosed deshelling mechanism followed by further cooling. The ingot is then picked up again, transferred to a semi-automatic descaling/breaking machine where all unfused or partially fused material is scraped off the ingots before the 100% fused MgO also named "core-material" is broken into larger chunks and forwarded to the crushing and sizing station and finally packed, loaded and shipped.

The older type Higgins fusing technology was chosen over the more modern semi-continuous casting or tilting technology mainly due to concerns of product quality, specifically crystal size. The tilt furnaces are very successfully applied in areas where the temperature needed to fuse the product is not as high, i.e. fused alumina, spinel, mag-chrome. The products can be molten and poured at temperatures about 2,200°C, versus the needed 2,800 - 3,000°C for high purity refractory grade fused magnesia.

MGO WORLD MARKET

Before discussing fused magnesia as a refractory raw material, I would like to spend a few minutes on the markets and applications for magnesia in general. As most likely everybody knows, MgO products are split into three categories: caustic calcined magnesia, sintered or dead burnt MgO and fused magnesia.

MgO is produced from two different sources, natural magnesite and synthetic, both are split down further. Two different types of natural magnesite exist, the coarse crystalline variety - such as Baymag magnesite and a micro - or crypto-

crystalline variety, mainly occurring in Greece and Turkey. Magnesia is produced synthetically using seawater or brines rich in magnesium salts. To put it in very simplistic terms, the advantages of MgO produced from a natural magnesite are lower energy and equipment costs while synthetic magnesia has the advantage of generally higher purity combined though with the problem of higher boron contents as well as higher production costs.

Only within the last two decades have magnesite ore deposits been discovered which are able to combine the purity, previously only to be reached using a synthetic process, with the energy efficiency of a process using natural magnesite. The purity of Baymag magnesite as one of the more recent ore discoveries is unequalled in the western world.

Table 2 gives an overview of the whole world market^{4,5,6,7} of MgO products. It clearly shows that while in the western hemisphere, natural and synthetic magnesia being about equally important, natural magnesite as a source for MgO is clearly predominant in the eastern countries.

TABLE 2: ANNUAL WORLD PRODUCTION OF MAGNESIA, M.T.

<u>World</u>	
Coarse Crystalline Magnesite:	5,670,000 (63%)
Crypto Crystalline Magnesite:	900,000 (10%)
Synthetic Magnesia:	2,430,000 (27%)
Total:	9,000,000
<u>Western Industrial Nations</u>	
Natural Magnesite:	1,600,000 (40%)
Synthetic Magnesia:	2,400,000 (60%)
Sub Total:	4,000,000
<u>Eastern Group of Countries</u>	
Natural Magnesite:	4,850,000 (97%)
Synthetic Magnesia:	150,000 (3%)
Sub Total:	5,000,000

Out of the total of about 9 million m.t., about 7 million m.t. are produced as dead burnt magnesia. Only about 100,000

m.t.p.y. of fused magnesia are so far produced and by far the major share of it is consumed in highly industrialized western countries. The remainder is calcined magnesia.

Figure 7 gives an overview of the applications of the three groups. Calcined magnesia is clearly the most versatile product. The most common product, dead burnt MgO is solely a raw material used for the production of refractory products, while fused magnesia, as a high value industrial mineral, is used as a specialty product in the electrical insulation field and becoming rapidly more important as a raw material for so-called magnesia-carbon brick refractories.

Not discussed in this paper are certain highly specialized production processes like the Aman, Sulmag and Ruthner process or insignificant applications, i.e. optical lensmaking out of fused magnesia.

Fused MgO - a refractory raw material, starting in the late 1960's, a trend developed to higher purities, somewhat later followed by higher densities and finally to a certain limit, increased single crystal sizes in dead burnt MgO combined with a decrease in total tonnage consumed. Led by Japan, the technology change in steelmaking to continuous casting, larger higher powered and water cooled electric arc furnaces, oxygen blown converters and ladles, used more and more for secondary-metallurgical after treatments of steel, put increased stress to refractory linings. The traditional tar or pitch-bonded sintered dolomite or magnesia bricks have not been able to fulfill all the needs of a refractory lining and subsequently superior refractories were developed for high stress areas, the polymer-bonded magnesia - carbon bricks.

It was not the refractory brick alone which could not properly respond to the needs any more, even the highest quality dead burnt magnesia was not the answer to all the questions.

Comparative studies showed that an increased percentage of fused magnesia replacing dead burnt MgO in magnesia-carbon bricks greatly enhanced its corrosion resistance as shown in Figure 8.⁸

Fused magnesia can be characterized by using the same criteria as for dead burnt MgO. These are chemistry or purity,

lime/silica ratio, bulk specific gravity (BSG) and the average primary crystal size. The main reasons why fused magnesia is superior to dead burnt MgO, even to the newest products of its kind, the so-called large crystal sinter, are the larger primary crystal sizes combined with a higher BSG and therefore lower porosity. Both lead to a reduction in inner specific surface area, which means that per unit of refractory lining, less area is available for any kind of chemical attack, may it be through liquid or gaseous infiltrations. This statement becomes immediately obvious in Figure 9 showing microscopic sections of a dead burnt and an ideally crystallized fused magnesia, side by side.

A lime/silica-ratio of well above 2 is desirable to avoid low melting Ca-Mg-silicates as interstitial phases. In the case that the lime/silica ratio lies below 2, merwinite (C_3MS_2) and/or monticellite (CMS) are formed, both having melting points around the 1,500°C mark. In case of a lime/silica ratio above 2 though, Ca-silicates (C_2S and C_3S) are formed which have melting or decomposition temperatures around 2,100°C. One cannot just go by the theoretically calculated lime/silica ratio alone since fused magnesia being a substance which crystallized from a high temperature melt with noticeable amounts of CaO, can be in solid solution with MgO and therefore not available to form the above discussed Ca- or Ca-Mg-silicates. Again, a lime/silica ratio of well above 2 is a must to ensure highest refractoriness of fused magnesia. This also is the main reason why electrical grade fused MgO in most cases is not suitable for refractory purposes, because for an electrical application, lime/silica ratios of well below 1 are desired and in certain products silica levels up to 5% are common.

Of course the user of fused magnesia always desires to get the purest MgO, best lime/silica ratio, highest BSG and crystal sizes and lowest possible Fe_2O_3 content. Intensive in-house research puts a serious question mark behind the must to have Fe_2O_3 values below 0.4 or even 0.3%. One reason for keeping the iron levels as low as possible is of course to stay away from the formation of low melting iron-containing compounds, which similar to low melting Ca-Mg-silicates could weaken the grain structure.

Another reason is that to a great extent unsubstantiated fear

While Baymag Fused MgO does not show the highest purity among the different samples analyzed, it compares very favorably with the other products in respect of lime/silica ratio, BSG, average crystal size and the phase composition done by X-ray phase analysis. One disturbing fact is that sometimes the theoretically calculated lime/silica ratios does not compare well with the actually identified secondary phases. This is an indication of, as discussed previously, various amounts of solid solutions taking place and on the other hand confirms that one has to be careful in theoretically calculating phase compositions based on the assumption of ideal homogeneity.

SUMMARY

Baymag, as the newest producer of MgO in North America, is controlling one of the largest and most pure coarse crystalline magnesite deposits on earth known today. Since 1982, calcined magnesia is produced - (today's capacity is 100,000 m.t.p.y.) followed by refractory grade fused magnesia in 1984. During 1989 a new 14,000 m.t.p.y. highly automated fusing operation came on stream. The unique combination of a superb raw material, cheap energy and most advanced production technology ensure calcined and fused MgO products of consistently high quality.

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⁶ Coope, B., Caustic Magnesia, Industrial Minerals, February 1987, P. 43-48

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FIGURE 1 BAYMAG MAGNESITE MINE



FIGURE 2: 6M BENCH OF SOLID
MAGNESITE ROCK AT THE BAYMAG
MINE

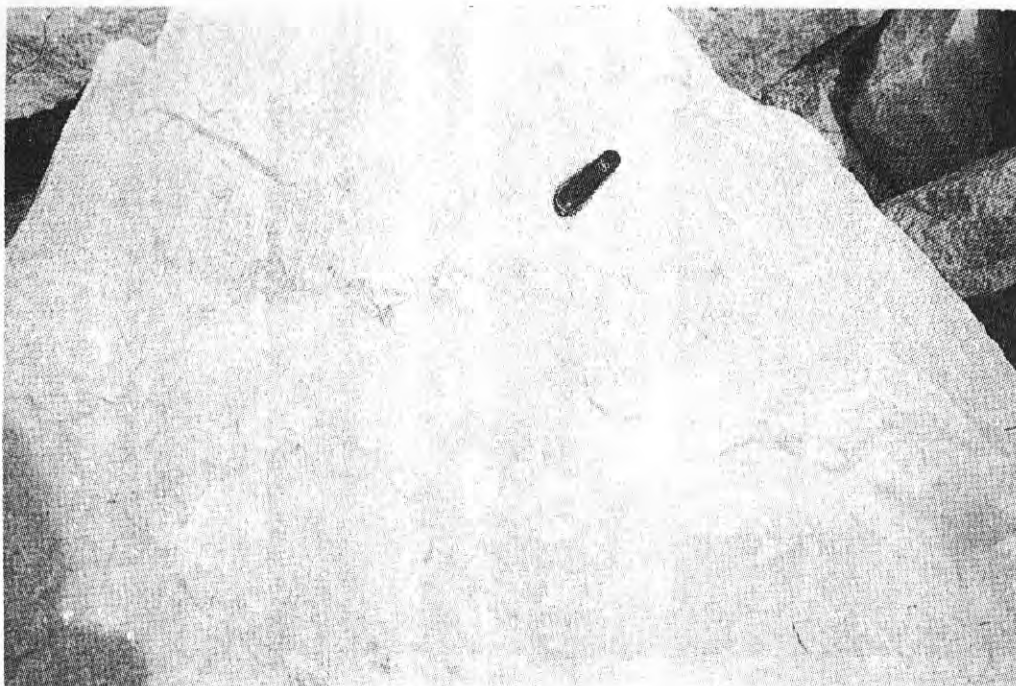


FIGURE 3: COARSE CRYSTALLINE BAYMAG MAGNESITE

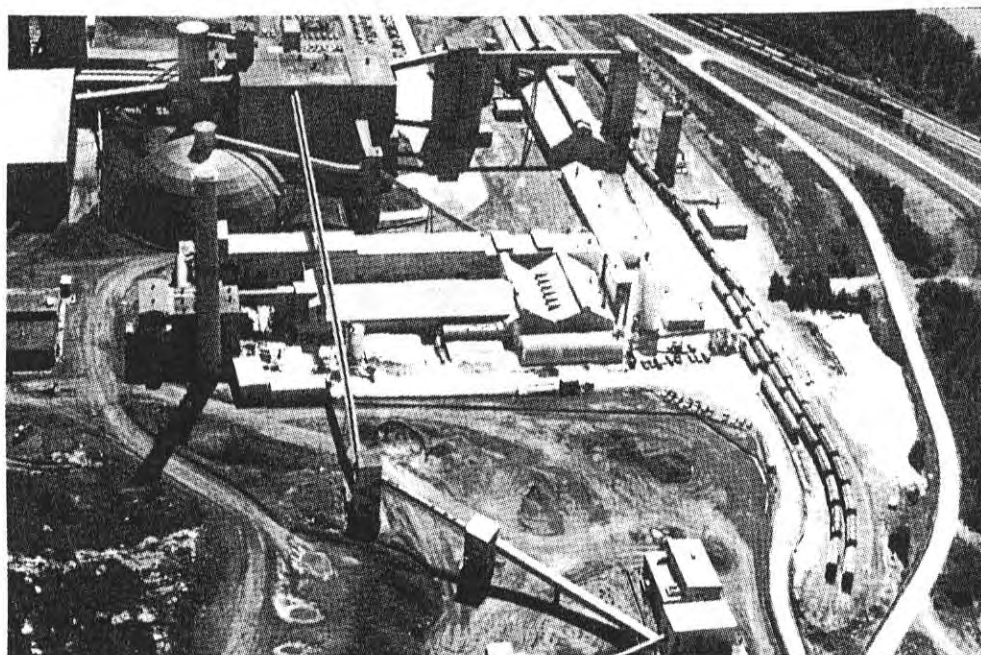


FIGURE 4: BAYMAG CALCINING PLANT

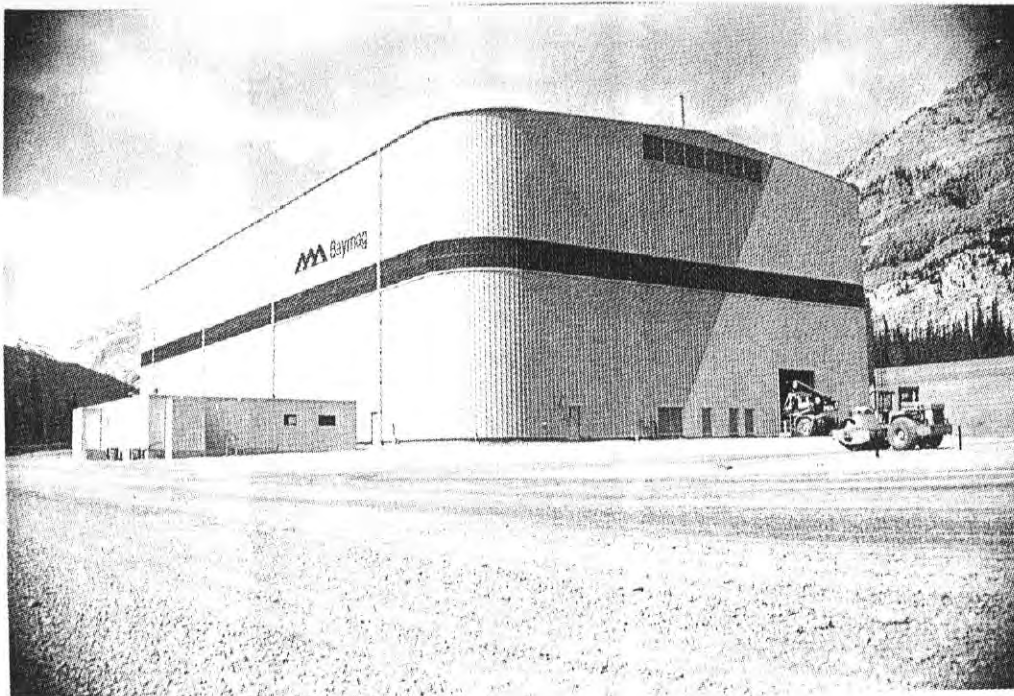


FIGURE 5: BAYMAG NEW FUSING PLANT

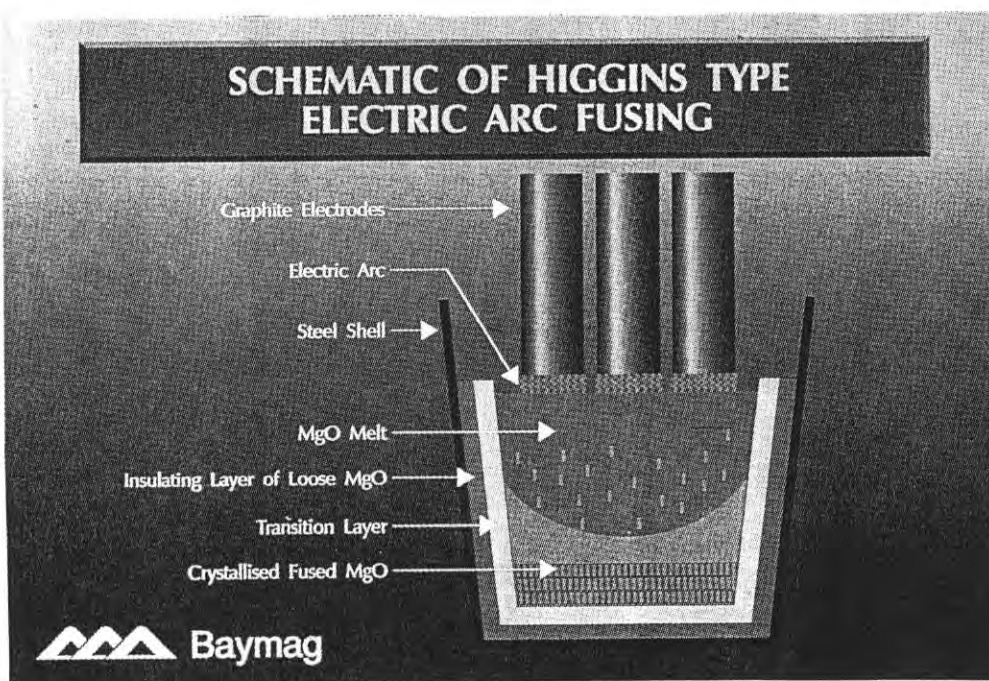


FIGURE 6: SCHEMATIC OF HIGGINS TYPE ELECTRIC ARC FUSING

INDUSTRIAL APPLICATIONS OF MAGNESIA PRODUCTS

CALCINED MgO

Acid neutralization
Animal feed supplement
Cellulose acetate
Epsom salt
Fertilizer
Flue gas desulphurization
MgO-based cements
Pharmaceutical industry
Pulp and paper industry
Rubber/rayon industry
Sugar refinement
Uranium refinement
Water treatment

DEAD BURNT MgO

Refractory products

FUSED MgO

Specialty refractory products
Heating elements



FIGURE 7: INDUSTRIAL APPLICATIONS OF MAGNESIA PRODUCTS

INFLUENCE OF FUSED MAGNESIA CONTENT IN MAGNESIA CARBON BRICKS ON THEIR CORROSION RESISTANCE

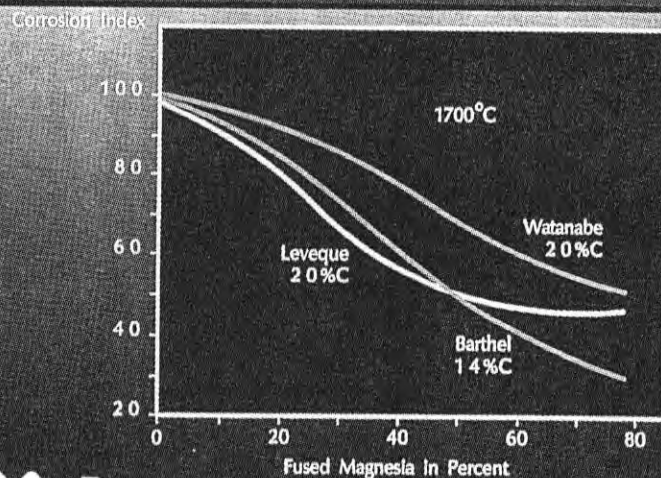


FIGURE 8: INFLUENCE OF FUSED MAGNESIA CONTENT IN MAGNESIA-CARBON BRICKS ON THE CORROSION

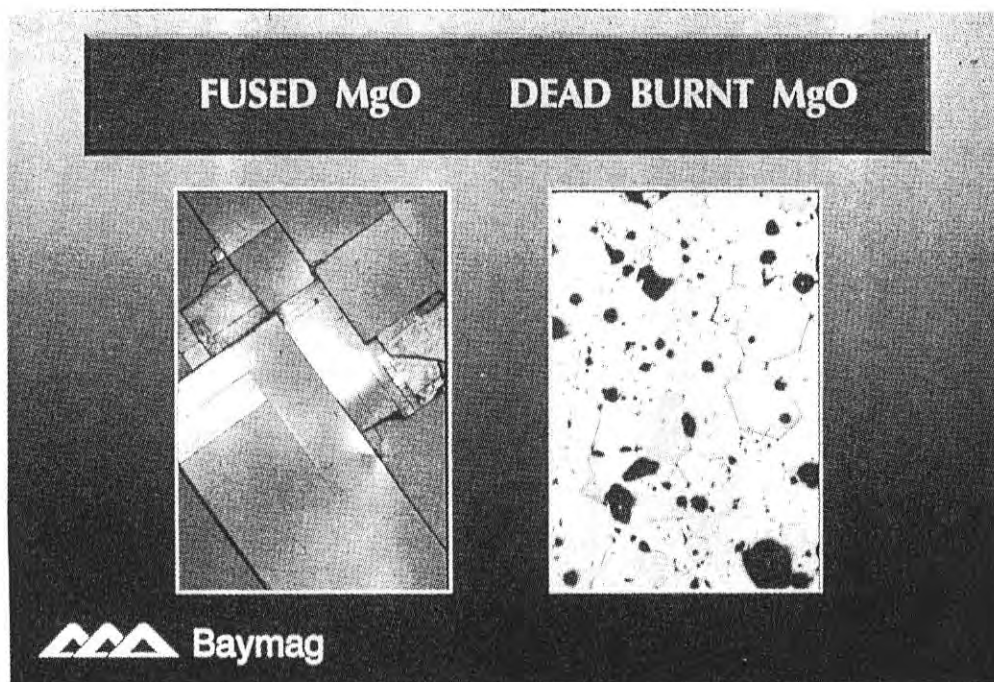


FIGURE 9: COMPARISON OF DEAD BURNT AND FUSED MAGNESIA