PN-AAJ-822

Magnesium Oxide Production in Tunisia: an Assessment

Agency for International Development
Washington, D.C. 20523

May 22, 1981

MAGNESIUM OXIDE PRODUCTION IN TUNISIA: AN ASSESSMENT

A Study for Trade & Development
Program, International Development
& Cooperation Administration by
Office of Engineering (DS/ENGR),
U.S. Agency for International
Development

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May 22, 1981

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I N T R O D U C T I O N

Kaiser Engineers, at the suggestion of the Tunisian Government Office of Mines, proposed in late 1980 that IDCA/TDP fund the engineering and construction of a Magnesium Oxide pilot plant in Southern Tunisia.

Kaiser did not undertake to advise Tunisia on the possible market for such Magnesium Oxide, considering this to be a responsibility of its client, the Government of Tunisia. As expressed when this project was first introduced: "The results shown by the pilot plant would hopefully confirm Kaiser's finding under its previous contract with the Office of Mines, i.e., that there is good potential for production of high grade, export quality Magnesium Oxide from the Zarzis pools." Note that this statement refers to the technical possibility of extracting high quality product, but not to its ultimate successful marketing.

Further communications speculated, however, that "this project has an enormous downstream potential", since (certain named) U.S. firms are considered world leaders in supplying this kind of technology. In further support, reference was made also to a Magnesium Oxide plant operating in Ireland using sea water as having "almost all U.S. equipment". Subsequent investigation has demonstrated these statements to be either extravagant (in the case of market potential and world leadership) or false (in case of Irish plant).

At the request of IDCA/Trade & Development Program, a definitional mission or pre-feasibility study was undertaken by the author during early 1981, using the methodology of indepth interviews of principal Magnesium Oxide manufacturers in the U.S. and Europe, together with equipment suppliers and such customer associations as the International Iron & Steel Institute.

In the report which follows--which constitutes a comprehensive industrial market research study--evidence is presented on the world supply vs. demand situation, the relationship of product pricing to quality, the situations with respect to competitors, customers, energy availability, and alternative products. The key importance of a marketing organization and its relationship to European cartels is discussed, together with the presence of a "dark horse" competitor in Central Europe which enjoys formidable advantages compared to any newcomer. The prospects for U.S. equipment purchases as a result of T.D.P. financing are specifically analyzed.

In the Appendix is a complete tabulation of existing world sources of Magnesium Oxide (Periclase and Magnesite), and a break-down of suppliers by grades offered and chemical analyses. As a suggestion, the reader is invited to examine the short articles on "Primer on Materials Nomenclature", together with "Significance of Product Quality" and the Appendices as a preferred way to preview this report.

It is recognized that Tunisia may wish to investigate all avenues of assistance, despite the findings of this report. Accordingly, in the concluding chapters suggestions are made in this regard.

S U M M A R Y and C O N C L U S I O N S

It is correct to assume that a limited quantity of high-grade Periclase will command a premium price, but it does not follow that the demand for such material is sufficient to support yet another contender in the face of an oversupplied market and declining world demand.

Based on a worldwide depression in the principal consuming industry, steel, projected to last into the 1980 decade, and a technological obsolesence trend (less Periclase per ton steel)--it is little wonder that many Periclase producers are either operating well below capacity or leaving the business altogether. Instead of pricing projected by Tunisian officials in the $550 or more per ton C.I.F. Rotterdam, it is established that the going rate for the largest part of world demand is in the $260 to $360 range, with waste materials finding a ready market in the $150 to $220 per ton region.

Energy constitutes approximately one-half of Periclase ("stored energy") production costs for European suppliers ($100 per ton) and somewhat less for U.S. producers ($70 to $100). Until recently, Tunisia energy cost would have been favorable by comparison, in the $45 to $60 per ton range, but a recent rise in tariff rates for the Algeria to Italy natural gas pipeline has erased most of this advantage. Tunisia is presently projecting to become a net energy importer by 1986-87, unless the very expensive Miskar offshore gas field can be developed.

By comparison to a potential supplier as far removed from the world's steel industry as Tunisia, several established producers enjoy a decided freight advantage by a more central location. Not the least of these is one (see "Dark Horse in the Periclase Picture") which sits astride one of the largest gas fields in Europe, within 500 km. of 80% of the European steel industry, which will supply highest quality Periclase based on a research program dating from 1975, and which enjoys a favorable financial backing from its parent, a major oil firm.

The key importance of established marketing channels and organization is reported, with the reality of "incestuous" cartels of Periclase producers tied-into steelmakers and brickmakers documented. It is, of course, possible that such arrangements could eventually be made by Tunisia, but the negative experience of Premiere Periclase (Ireland) in trying to sell product <u>despite</u> its preferred position in such a cartel does not argue well for a complete newcomer so far removed from the European scene.

In the face of a world oversupply of Periclase, could a new producer choose instead to enter the faster growing caustic Magnesia business? Unfortunately not with any promise of success, since Periclase producers with existing plants are already diversifying into this field, more than satisfying the growing demand. This "odd lot" business is found to be very fragmented, requiring exceptional quality control, seldom involving long runs and largely "locked-up" by specialty chemical manufacturers. Even the newest use for Magnesia--scrubbing of sulfur dioxide from coal gas plants--is found to be a highly limited market and well supplied by existing Magnesia producers.

Since the mission of the Trade & Development Program is to promote exports by U.S. suppliers, it becomes necessary to question the probable level of sales to an ultimate Tunisian Magnesium Oxide plant. To answer this question, each of three European producers (Steetley, Billiton and Premiere) are analyzed. Based on guarantees, competetive pricing, favorable financing and proximity, European suppliers enjoy a decided advantage over U.S. and the pay-out on the required $300,000 to $500,000 T.D.P. investment is found to be well below predetermined standards.

Despite the overwhelming evidence which would argue against prudent investment in this venture, either by the Government of Tunisia or T.D.P., it is quite possible that our Tunisian friends may wish to pursue the project with other sources of financing. With this in mind, observations are offered concerning technical assistance available on a fee basis, both in the U.S. and Europe, together with observations on raw materials, Kaiser's cost estimates, and indication of interest from two private sector joint venture candidates which could be explored further.

In any case, based on data presented in this study, it becomes necessary to urge particular caution in terms of Government of Tunisia entry into this market or IDCA/Trade & Development Program financing of a proposed pilot plant.

A PRIMER ON MATERIALS NOMENCLATURE

Pure Magnesium Oxide (MgO) has a theoretical melting point of 2800°C, thus placing it in the class of refractory oxides. However, there are many commercial grades of Magnesium Oxide, ranging generally from 86 to over 99% MgO, whose physical properties depend upon starting materials and method of manufacture.

Magnesium Oxide is formed when Magnesium Hydroxide or Magnesium Carbonate is calcined, or heated to very high temperatures. The former source material is precipitated from sea water or brine using Limestone or Dolomite, whereas the latter is mined as Magnesite, a naturally-occurring Magnesium Carbonate mineral. Low temperature calcination (900°C) produces a chemically soluble and reactive product known as caustic calcined Magnesia. High temperature calcination (1500 - 2000°C) given an unreactive insoluble material known as dead-burned and used in refractory products principally for the steel industry.

In this report, hard-burned Magnesium Oxide from either sea water or brine sources is uniformily referred to as Periclase (94 to over 99% MgO) to distinguish it from Magnesite, the ore mined from the earth which is a competetive or substitute material of generally lesser purity (85-87%). In the trade, however, both are often referred to as Magnesite and the principal use of these materials is in high-temperature steel refractories.

In the case of soft-burned Magnesium Oxide, this is referred to both in the trade and in this report, interchangeably as Magnesia or caustic or chemical grade material. Here the uses are far more varied, although in much smaller quantities, for such applications as fertilizers, pulp and paper treatment and flooring cement. Again, natural Magnesite is the main competition for caustic-grade Magnesium Oxide recovered from sea waters or brines.

SIGNIFICANCE OF PRODUCT QUALITY

Fundamental to an appraisal of the Periclase market is an understanding of product quality significance. Over three-fourth of Periclase production goes into refractory bricks for the steel industry. Since high hot-strength and slag resistance are prerequisites for this service, what are the physical properties required to achieve these refractory characteristics?

First of all, a maximum Magnesium Oxide content preferably 98% or better is desirable, to take advantage of the theoretical melting point of 2800°C. Secondly, a high Calcium Oxide/Silica ratio, approaching the composition of Dicalcium Silicate. This is important to avoid silicate formation with lower melting points, such as 1000°-1200°C, instead of the close to 2000°C possible in highest grades of commercial Periclase. Again, presence of Boron Oxide (B_2O_3) is a decided detriment, since this element can act as a "flux" to facilitate low-melting point silicate formation. A Boron Oxide content of less than 0.03% is desirable, and as little as 0.005% is possible. Next to Boron Oxide, other bad actor contaminants (in order to harmfulness) are Aluminum Oxide (Al_2O_3) and Iron Oxide (Fe_2O_3).

Thus, it is seen that the final product can necessarily be no purer than its antecedent raw materials, namely, the magnesium source and the Limestone or Dolomite used to precipitate Magnesium Hydroxide for subsequent sintering to Magnesia (caustic-grade) or Periclase (dead-burned grade).

Finally, in the matter of physical properties, a minimum density of approximately 3.4 grams/cubic centimeter and a porosity of less than 3-4% are desirable for maximum slag resistance in steel production.

To visualize the refractory raw materials situation in general, imagine a pyramid (Exhibit 1) with low price high volume raw materials at the base and high value low volume materials at the top. Refractory companies produce standard bricks or blocks by the millions, using cheap and often waste materials, such as in Classes IV and V of Appendix A. Economy is achieved by mass production. The high quality Periclase products (Classes II and III) fall into the middle ground outside the mass produced block making operations. At the apex of the pyramid are the premium (Class I materials) demanding high quality control and expensive refractory processing. Although unit prices are high here, the total volume is obviously very low.

To illustrate the large differences between grades differing by only 1 or 2 per cent in Magnesium Oxide content, we may consider the classification used by Dow Chemical Company, a major supplier to the refractory industry of Magnesium Hydroxide. Exhibit 2 depicts these relationships, which show the relative rarity of highest grade (99.5%) Magnesium Oxide, with the great bulk of grades falling in the 94-99% range. This graph also illustrates vividly the key importance of Boron content, in differentiating between premium grades and run-of-the-mill grades.

Given these desired physical properties, where in the world can such

Exhibit 1

REFRACTORY PRICE VS. VOLUME
RELATIONSHIP

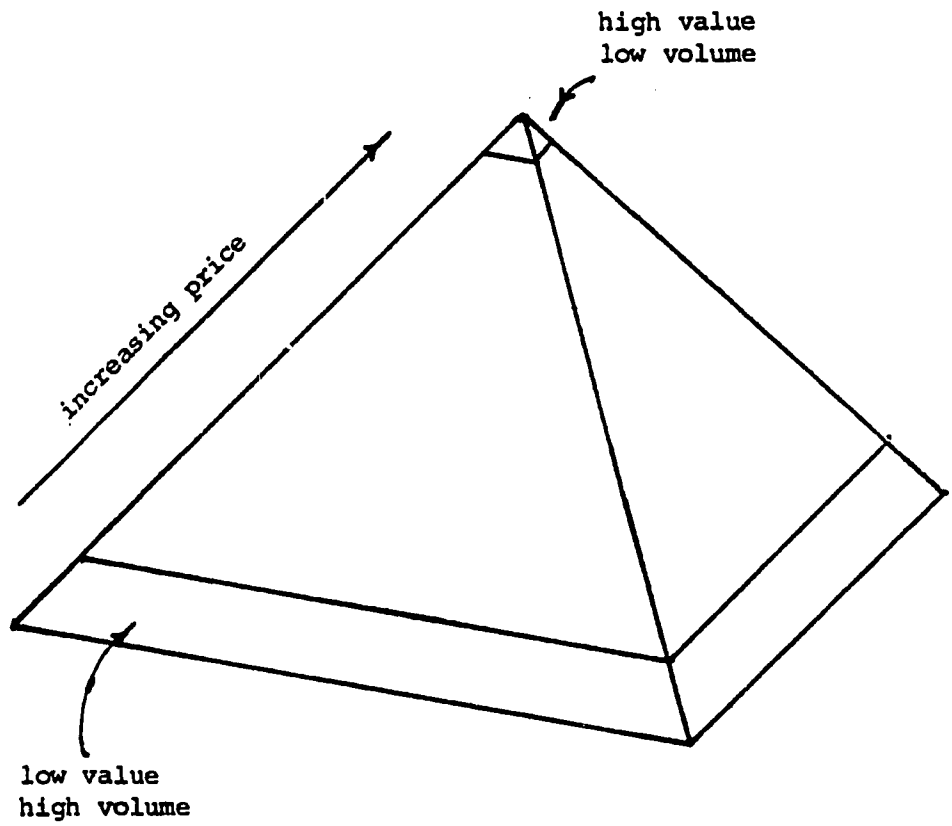
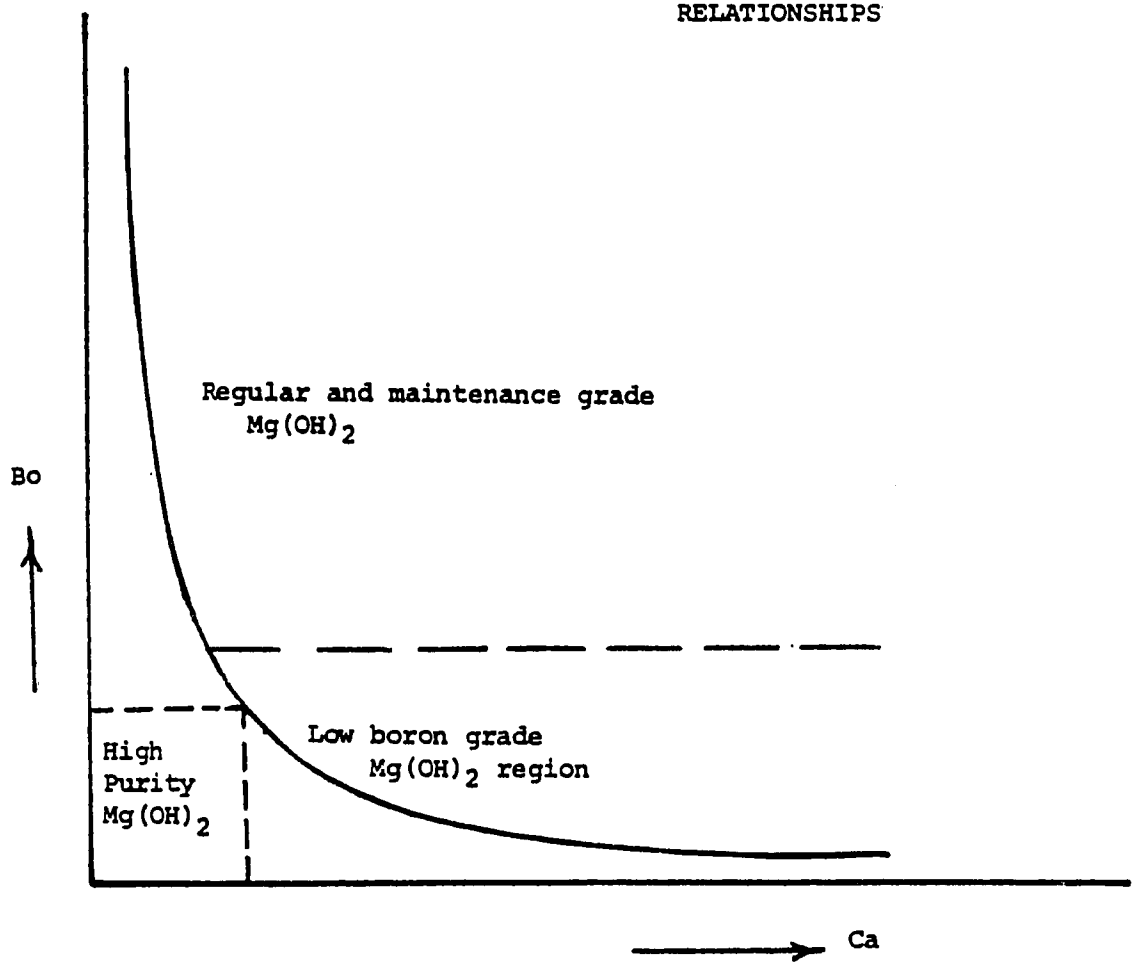


Exhibit 2

PERICLASE GRADES
VS. PURITY
RELATIONSHIPS



GRADE	MgO	CaO	SiO_2	B_2O_3
High-Purity	99.5%	0.4%	0.1%	Less than 0.1%
Regular	98-99	Less than 1.0%	Less than 1.0%	Less than 0.2%
Low Boron	96-97	Less than 3.0%	" "	Less than 0.5%
Maintenance	94-95	Less than 3.0%		0.2-0.4%

material be obtained? A comprehensive answer to this question is provided in Appendix A, which subdivides Periclase into six classes, according to MgO content, CaO/SiO_2 ratio and B_2O_3 content. In the companion table (Appendix B), names of actual companies supplying products in each category are classified, together with representative analyses of important elements and bulk density.

From this listing it can be seen why Dead Sea Periclase Ltd. of Israel is universally regarded as providing one of the highest grades of Magnesium Oxide. In point of fact, Ube Chemical Industries of Japan is not far behind, being equal in MgO content but less desirable in terms of Lime/Silica ratio or Boron content. Steetley Minerals of Hartlepool, England, is a major factor in supply, but not of prime-quality grades, attributable to the quality of available Dolomite raw materials used in Magnesium Hydroxide manufacture. On the other hand, COGEMA of Sicily and SARDAMAG of Sardinia offer higher purity material than parent Steetley, equivalent to brine-based Periclase from Martin Marietta, one of the largest U.S. manufacturer in Manistee, Michigan.

In terms of quality and proximity to the European steel market, the real "dark horse" to watch is Magnesia International (Billiton) at Gronigen, The Netherlands. Based on laboratory and pilot plant tests to date (an extensive development program dating to 1975), informed sources place Billiton product either in Class I or "somewhere between" Classes I and II (Appendix A and B). Some sources also feel that Premier Periclase of Drogheda, Ireland, based on its pure Limestone source, could upgrade to the Billiton standard.

It is indeed true that higher-purity Periclase opens up a higher-priced market. The more fundamental question, however, is how many companies are going after this small market segment (Exhibit 1), and with what capabilities and resources already proven, either in the marketplace or by advanced pilot plant development.

WORLD SOURCES OF MAGNESIUM OXIDE

Tunisia is surrounded by Near East countries which are historically major producers of both high-purity Magnesite and Periclase from sea water or brine. In the latter category are Cogema in Sicily, Sardamag in Sardinia and Dead Sea Periclase in Israel, the latter producing some of the purest Magnesium Oxide in the world. Natural Magnesites from Greece and Turkey are considered to be serious competition because their low energy requirements (single-burn only, rather than dead burning required) make them more cost-effective than sea water Periclase, with only nominal sacrifice in purity. It is claimed that Dead Sea Periclase will undergo enlargement by 50 per cent in the near future. Scalistiri of Greece (Financial Mining Industrial & Shipping Corp. or FIMISCO) is one of the best known Magnesite producers in the world. Turkey is reported to have substantial capacity, in the region of 200,000 MTY, and to be "looking for customers".

Equal or greater competition may be expected from the Austrians and Yugoslavians, which have enjoyed a firm hold of much of the world trade in Magnesite for the past 15 to 20 years. Veitscher, the principal competitor to Osterreichisch Amerikanische Magnesit, A.G. is reportedly tied-in with the Turks to produce quality Magnesite in Turkey. As noted above, this lower-grade Magnesite is of surprisingly high purity and requires only 40% as much heat as sea water Periclase. It is highly competitive with Periclase when steel demand is down, being useable in the form of a gunnite mix without requiring shut-down of furnaces between runs.

Next door to Tunisia is Libya, whose Marada brines were the subject of a 1979 study by McKee-Tractional of Brussels for the production of refractory grade Magnesium Oxide, based on low-cost energy availability. In 1975, FIMISCO was authorized by the Greek Government to construct a 100,000 MTY sea water plant, estimated at $50 million, but this was postponed indefinitely because of lagging demand for steel production. Jordan, meanwhile is considering production of 50,000 MTY of Magnesium Oxide as a by-product to its Dead Sea Potash operation. Other Arab countries reported interested in exploiting Magnesium sources include Morocco, Algeria and Egyrt.

As pointed out by Premiere Periclase, if the Russians, Chinese or Canadians (BayMag in British Columbia) ever come on-stream with their gigantic high-grade Magnesite deposits, the world competetive position will be worsened dramatically.

Europe, of course, is a prime contender in the sea water Periclase business. Personal visits were made by author to the oldest producer, Steetley Minerals in Hartlepool, England; to a relative newcomer, Premiere Periclase of Drogheda, Ireland; and to the newest, and probably most formidable contender, Magnesia International (Billiton Minerals) in Gronigen, The Netherlands. Under the heading, "Dark Horse in the Magnesium Picture", Billiton's operation are discussed elsewhere. Both Steetley and Premiere are aggressive in seeking market outlets for their Periclase, in the face of a declining steel industry. Norway is also reported to produce Magnesium Oxide, based on its immense

hydroelectric power resources, but location is presently unknown.

A less obvious, but growing presence in the European Periclase industry is Germany. Initially importers of Magnesite, Germans are now reported producing Magnesium Oxide in the northern sector of East Germany from a waste Potash brine. A joint-venture involving a steel cartel is rumored. Meanwhile, West Germans make some of the best briquetting machines available to the industry, and the Germans (together with the Japanese) enjoy a reputation for astute dealing in this industry. This, in fact, offers a possible entree for Tunisia, in that both Germans and Japanese are known to give extensive credits in financing desirable new plant construction, and to be willing to take a percentage of product (possibly including Periclase) as partial repayment of loans advanced.

On the other hand, the very large German chemical producer B.A.S.F. considered Magnesium Oxide extraction from sea water by its subsidiary Kaliundsalz, but apparently abandoned the project, for whatever reason. Professor Luck of University in Marburg (Hessen County near Frankfurt) started this project and may be contacted for more details.

For two years, Premiere Periclase has been trying to sell Periclase to Poland, but without success. This is not surprising when it is realized that the CONECON countries (Communist common market), while experiencing problems of their own, tend to be interdependent and independent of the West. Thus, a 30,000 to 40,000 TPY Polish market for high-grade Periclase and/or Magnesite is supplied mostly from Czechoslavakia, Yugoslavia and Brazil. The Russians have "vast" deposits, and sales to them are essentially ruled out. Roumania has built a 100,000 TPY plant to cover its own needs estimated at 50,000 TPY with expectations to export the balance. In this case, Roumania starts with an existing need for refractories for its domestic steel industry.

Harbison-Walker spent three years designing Periclase plants for Yugoslavia, Greece and Norsk Hydro of Norway. None have actually been built, however, even after test trials. Reason: Principals in each of these countries backed-off on grounds that return on investment was insufficient. "They were O.K. the first year", explains Development Director Ed Einstein of Harbison-Walker, "but not three years later".

A sleeping giant in the Magnesite business is The People's Republic of China. As verified by the 1980 American Ceramic Society field trip to China, Magnesite reserves of this nation are estimated at more than one billion metric tons. Mining is accomplished at two large sites in Liaoning Province (northeast China) and loaded for world Markets at the Port of Luda (Dairen). Both modern shaft kilns and rotary kilns are used for dead-burning of Magnesite.

Quality of this material is considered uniform and "quite good", according to General Refractories President John Hartshorn. Out of the 600,000 to 700,000 tons of ore mined annually, estimates of export activity range from 50,000 to 200,000 TPY. No doubt this will grow, "sooner than we think", according to Hartshorn.

Other Asian countries are even more active. Although its capacity is much smaller, North Korea is claimed able to land Magnesite in Rotterdam at less than $150 per ton. A far more significant competitor, however, is Japan. Ube of Japan accounts for 450,000 to 500,000 MTY of dead-burn capacity, and exports an estimated 60% of this to the U.S. market. Asahi has an installed capacity of 265,000 TPY, and Shin Nihon adds another 100,000 tons.

Potentially formidable competition is slated to come from an "upcoming" power in Magnesium Oxide, namely Mexico. Mentioned both by General Refractories and Harbison-Walker, Mexico's Magnesite quality was labeled as "unquestionable", and its brine sources as "superb". In the opinion of John Hartshorn of General Refractories, nobody will be able to compete with Mexico, which has the advantage of cheaper power and a home market for refractory Periclase, as well as good raw materials. "They will be able to beat anybody on price", he concludes.

In the case of Brazil, its Magnesium Oxide industry enjoys a reported 40 per cent export refund credit. This "subsidy" is a source of irritation to some European producers, who claim Brazil (like North Korea) can land good quality Magnesite for less than $150 per ton in Rotterdam. Also in the Ameri. Canada enjoys a huge deposit of natural Magnesite in Kootenay Bay, British Columbia. The Germans were reported involved in developing this deposit, but apparently have discontinued.

Not the least competetive threat in the Americas is the United States itself, with plant expansions underway or completed by two of the largest U.S. suppliers, Martin-Marietta in Manistee, Michigan and Basic Refractories in Nevada. In addition, Dow Chemical's dominance of the Magnesium Hydroxide field (raw material for Magnesium Oxide) is based on many years of research and commercial development. Dow, in fact, is the principal supplier of this product to both Martin and Harbison-Walker, at Manistee and Ludington, Michigan.

Some European Magnesium Oxide industrialists as a matter of fact, speak disparaginly on the "invasion" of the European market by U.S. exporters, who enjoy a cost advantage based on lower fuel prices.

WIDESPREAD OVERSUPPLY OF PERICLASE

A tell-tale sign of overcapacity in the Magnesium Oxide business is found in the operational status of existing plants, in terms of present production level versus design capacity. Steetley Minerals of Hartlepool, England, is one of the oldest in Europe, yet is reported operating (by one estimate) at 50% of full capacity. Sardamag of Sardinia, tied-into Steetley, is reported at least temporarily shut-down since December, 1980. High fuel costs and lack of business are blamed.

Likewise, General Refractories reports its Saloniki facility (Salonica) is phasing-out, and its Austrian mines are operating below capacity. Veitscher of Austria, General Refractories' biggest competitor, is also reported operating below capacity. In the same part of the world, Scalistiri of Greece is very large, and markets a high-purity Magnesite (Super Mag-Flot) that is competitive with synthetic Periclase. Michael Scalistiri is reported to have backed-off building a sea water plant four years ago, preferring instead to improve beneficiation facilities to upgrade his Magnesite deposits. In the United States, Corning Glass Co. of Pascagoula, Mississippi, is reportedly running part time, preparing to shut-down.

Premiere Periclase of Drogheda, Ireland, is an interesting special case with a story. After learning from Kaiser Aluminum that Premiere was considered to be in "dire straits", author visited this facility personally and interviewed its top management personnel. These facts are particularly interesting when one asks, "Why would a company consider starting a new Magnesium Oxide business in the face of a supposed world oversupply situation?" (The same question was asked of Billiton personnel in Amsterdam and Gronigen, but the answer was entirely different). In the case of Premiere Periclase, it turns out that in 1975 an old cement plant had to be closed, and 120 people either laid off or new employment found for them. Many alternatives were considered, including production of Periclase, which was the ultimate choice. In the 1975-76 time period, the market was less soft and actually growing with good projections into 1980. At that time, the former management team (Paddy Dogherty was plant manager for the then cement plant) saw Billiton as "unlikely" and witnessed Scalistiri postpone his sea water Magnesium Oxide plant (which was subsequently not built). Then the bottom dropped out, and steel "went down to the floor" from 1977 onward, according to Dogherty.

At this point, Premiere Periclase is scratching for business without great success. One symptom at the time of this interview was that plant was shut down for routine maintenance, which would normally be done "round the clock" but was scheduled for five weeks in view of reduced volume and operating time. In fact, enroute to the plant, author was informed by driver that this plant is presently operating on a 3-day per week schedule, and that unemployment is a key problem in the area.

Even in the words of an in-house Kaiser consultant (Ore Olsen of Kaiser Aluminum), the general market for Periclase in Europe is "terrible" at this time, and "not likely to get better soon." In three years time, when a new

plant might be on stream, it is "hard to say" what the situation might be, claims Olsen.

Not only is the market for synthetic Magnesium Oxide "stagnant", but "there is plenty of Magnesite around, even if steel were at 100% of capacity", states Consultant Fred De Naestri of San Francisco. De Naestri is widely recognized for having built five separate sea water Magnesium Oxide plants, including the Kaiser Moss Landing, California plant. What is needed for a new producer, he explains, is an internal steel industry and market for Periclase (Spain is an example of a country with good brine deposits, yet importing Periclase for its steel industry). "If plans are to produce Periclase just for export, this is not the right direction to head", claims De Naestri. This would be "throwing more on a market that doesn't need it", he concluded.

More pointed is John Hartshorn, President of General Refractories, who asks, "With so (deleted) much Magnesite around, where are you going to ship it"? Periclase and natural Magnesite are not a growth area, he emphasizes, citing the 1 million ton U.S. market as "fully satisfied" and the nearly identical Europe market of 1 million tons per year as "saturated". Hartshorn estimates at least 20% more dead-burned Magnesium Oxide (Periclase) is now on the world market than will be needed for the next 5 years. As far as the U.S. market is concerned, it is cheaper for General Refractories to buy premium synthetic material from Martin-Marietta in Manistee, Michigan, than to import less pure Magnesite from Europe.

Echoing these sentiments, General Refractories' Austrian subsidiary Osterreichisch-Amerikanische Magnesit AG points out that, after Billiton comes on stream this year, "overproduction of Periclase is certain, especially with the low production of steel in Europe".

These remarks, by the President of General Refractories and the General Director of its principal subsidiary might be taken as somewhat biased, since they are in the Magnesite business. On the other hand, General Refractories is a net buyer of Periclase and imports some 55,000 TPY of the synthetic material. Consequently, world overproduction of Periclase with consequent lower prices would be in their favor. Furthermore, General Refractories (and R.C.F., its Austrian engineering consulting arm) would be interested in supplying technology to Tunisia, just as it has done for Billiton, Israel, North Korea, and others. In this case, General Refractories would not desire an equity position in a Tunisian venture, but would participate only on a straight fee basis, paid "up front". "Tunisia is not a threat to General Refractories", Hartshorn adds.

In a more specific vein, Premiere Periclase's General Manager, Pattrick Doherty estimates a 300,000 to 400,000 MTY surplus of high-grade (96% + MgO) Periclase with controlled Lime/Silica ratio to be available to the European steel industry. Based on 160 million tons of steel production and 1.8 to 2.0 kg. MgO per ton, Doherty submits that approximately 300,000 MTY Periclase are thus required. (We may compare this with a higher estimate of 3.0 kg. MgO per ton, or up to 450,000 MTY Periclase requirement). Against this, he projects the following supplies of Magnesite (high grade only) and synthetic Periclase being presented at present to the European market:

Premiere Periclase	80,000 tons	
Sardamag and Cogema	170,000	
Steetley	70,000	
Dead Sea Periclase	45,000	
Scalistiri (Greece)	120,000	(Super Mag-Flot)
Other Greek suppliers	60,000	
Turkish suppliers	70,000	
Ube and Asahi (Japan)	35,000	
	650,000 tons	

Dow Chemical Company, an important basic supplier of Magnesium Hydroxide, left the Magnesium Oxide business as such in 1975. Why? If one is seeking clues for the health of this industry and the prospects for new entrants, one should naturally ask this question. Examination of supply and demand data for dead-burned Magnesium Oxide shows that demand bottomed in 1975, being heavily outpaced by world supply. As explained by Robert Hansen, Operations Manager for Brine Chemicals, Dow found that it couldn't make adequate money in Magnesium Oxide, partly because of competition against sometimes non-profitable manufacturers with captive facilities. Dow did find its unique slot, however, as the largest U.S. supplier of the precursor raw material Magnesium Hydroxide, which it sells to two of the biggest and oldest U.S. producers located nearby in Michigan, namely Martin-Marietta in Manistee and Harbison-Walker in Ludington. In addition, Dow is well-known as one of two major world suppliers of Magnesium metal, from its plant in Texas.

The nature of the Periclase market is essentially cyclical, described by Consultant James C. Hicks of San Francisco as "like a yo yo, worse than the stock market". He cites a shortage two years ago, but currently an oversupply based on world steel industry working at only 60 to 70% of capacity. "It should give anybody involved a lot of concern", concludes Hicks. Consultant Fred DeMaestri of San Francisco, builder of five sea water MgO plants, confirms that the Periclase market resembles a sine function curve in configuration, "sometimes up and sometimes down". R.C.E.'s Managing Director, Gunther M. Jungmeier of Randenthein, Austria (subsidiary of General Refractories in U.S.) likewise confirms the "economic cycle" of Periclase, being currently in excess and sometimes deficient.

For comparison, what would be the sentiments of a firm which is completely dependent upon imported Periclase, and produces none of its own refractory raw materials? Such a company is North American Refractories of Cleveland, Ohio. Executive Vice-President Ed Wright confirms that "somebody must get out of the business", adding that without restriction to grades, "there is a definite surplus in Europe." Here the qualifying phrase "without restriction to grades" is revealing, and explains NARCO's potential interest in a new source of supply such as Tunisia. Wright explains that NARCO's success has been based on its past ability to find high-quality Magnesium Oxide at good prices, and that they do "a lot of looking". At present, NARCO reports it is

negotiating a contract which could account for one-half of its future purchases, so that its total demand may drastically decrease before a Tunisian plant could be built.

Periclase is not really akin to the scrap metal business, according to Wright. Rather, he feels, "serious" people in this business are very conservative, and negotiate long-term purchases and thereby insulate themselves from wide price and supply swings. He does acknowledge, however, that NARCO did have to "negotiate widely" with Scalistiri of Greece some 5 to 7 years ago, when his high-purity Magnesite was selling at $100 to $160 per ton.

INTERNATIONAL DEPRESSION IN STEEL

Are there fundamental reasons for this wide oversupply of Periclase? One such reason is certainly the status of the world steel industry, which is by far the largest user of Periclase in the form of refractory grade bricks to line furnaces.

Perhaps the most unbiased viewpoint of Periclase's future in Europe is that of the International Iron & Steel Institute in Brussels, Belgium, since it represents many consumers of this refractory-grade Magnesium Oxide in the world steel industry and is not seeking the sale of this material. Indeed, Chief Economist D. Oscar Anderson was most helpful in elaborating the depression in steel and the technology changes in steel which have led to a decreased use of such Periclase per ton of ingot steel (c.f., "Unit Steel Consumption of Periclase in Downtrend").

As far as the steel industry itself is concerned, Anderson documents a decline from 6-6½% growth in the western world's steel industry in the 1960 decade to only 0.24% in the 1970s. For the CONECON countries (Russia, E. Europe and Cuba), the corresponding rate has dropped from 5-6% to 2-3% in the 1970s. Japan decreased from 15% growth in 1960s to only 2% in the 70s, and may be able to maintain this rate, despite cuts in its auto and shipbuilding industries.

Foreseeing a continuation of these trends into the 1980 decade, Anderson predicts that the future of steel is clearly down, calling for an obvious decrease in Magnesium Oxide refractory use, all aside from the decreased use per ingot ton of steel produced. Worldwide, he says, steel is in a cost-price squeeze and "stagflation". In Britain, France, and Italy, steel bankruptcies have been averted only by government intervention. The Germans have taken least subsidies, despite a drop from 56 million tons of steel production in 1978 to only 42 million tons in 1980. "Even the Americans", in the form of Social Security payments, have subsidized steel unemployment, he notes.

In a recent cable from American Embassy in Brussels, Societe Generale's Governor Lamy is quoted as stating: "1980 was a particularly difficult year for the whole of the European iron and steel sector" and "---the extremely difficult position of the iron and steel sector remains a problem of grave concern for us". These remarks are significant in that the Belgian Government looks to Societe Generale to supply complementary steel financing under its steel restructuring plan, and such banks have stalled for some months on this subject.

Again, considering Great Britain, Noel Heasman of Steetley Minerals refers to the three month steel strike in 1979 which was followed by a reduction from 25 million tons capacity to only 21 million in 1980 and more recently to only 15 million tons. In 1981, he predicts a further cut to 11 or 12 million tons, a decline since 1979 of over 50 per cent. This he terms a "permanent, fundamental weakness" in the British steel industry.

Still other evidence of the world depression in steel is a recent note in the financial press which headlines, "Crude Steel Output Plunged 16% in Japan Last Month to Lowest Level in Two Years". Actually, the decline is more like 75%, from a high of 32.2 million tons in the April-June quarter of 1980 to the current 8.6 million ton level. This is based on steelmakers' high inventories and slow demand in the Japanese construction and auto industries, according to the Japan Iron and Steel Federation.

LESS PERICLASE PER TON STEEL: A TREND

Even if steel production had held at 100% of capacity, which is far from true, the unit consumption (pounds MgO/ton steel) has declined significantly with improved steel technology. Thus, the old open hearth furnace--once the industry standard and now almost extinct--demanded 45 to 55 pounds of MgO refractories per ingot ton of steel. When electric arc furnaces gained popularity, the consumption was originally about 15 pounds MgO/ton steel. Further refinements in the art of steel-making have reduced this figure to the range of 4½ to 6½ pounds of MgO per ingot ton steel, both for the Basic Oxygen Furnace (replacing the open hearth) and the electric furnace--not much more than one-tenth (10%) of historic, open hearth consumption.

Other technical developments in steel manufacturing exacerbate this trend. First, water-cooled refractories are replacing refractory bricks, especially in the walls of Japanese electric arc furnaces. Speaking of the Japanese, large savings in raw materials (including refractories) have been realized there and elsewhere by development of continuous casting. To be specific, 1.0 ton of finished steel formerely required 1.4 tons of raw steel, but today requires only 1.1 ton with continuous operation--a savings of 21% in refractories and other raw materials.

But how can furnaces be operated continuously, without closing down to replace bricks? Simply by the use of crude Magnesite "gunning" mixes (like gunnite), sprayed into the hot furnace to replace damaged refractories, without shutting down the furnace. For this purpose, an impure 80 to 90% MgO material is adequate, such as supplied by Martin-Marietta at a fraction of the high-purity refractory brick material cost.

Additionally, refractory life has been extended, important when steel consumption is down so drastically, by "doctoring" the furnace slag with chemical additives to match better the basicity of the particular MgO bricks used. Improvements in the physical properties of linings (high density, low porosity, high MgO, high Lime/Silica ratio, low Boron content) can come both from the quality control of Periclase suppliers and from the art of the brick-makers. This, however, is somewhat self-defeating in that improvements lead merely to longer-life refractories and lower demand for replacements.

WHAT IS REALISTIC PRODUCT PRICING?

What constitutes realistic pricing in the Periclase field? This depends upon quality. Most expensive is the premium Dead Sea Periclase product, ranging from $550 to $570 per MT C.I.F. Rotterdam. "Everybody wants some" for brick-making, explains General Director Karl Leitner of Osterreichisch-Amerikanische Magnesit AG of Randenthein, Austria. This general high demand tends to keep its price up, but present capacity of Dead Sea Periclase is limited to 45,000 tons per year. Expansion plans of 50 per cent are being discussed.

This is the competetive material against which Government of Tunisia ONM officials have gauged their chances of success, believing that they can produce Periclase for $350 per MT ex. factory and land in Rotterdam at $450 per MT C.I.F. To determine if this is a fair and realistic picture for competetive pricing, we must examine other suppliers and their pricing, and relate these to grades and quantities sold.

"Serious buyers" of Periclase, estimates Dow Chemical's Brine Business Manager Richard Dolinski, are paying $250 to $260 per MT, in lots of 10,000 tons or more. This, of course, would not apply to Dead Sea grade Magnesium Oxide. A more definitive estimate comes from E.S. Wright, Executive Vice President of North American Refractories of Cleveland, Ohio, who estimates $275 to $360 F.O.B. plant applies to the bulk of consumption (estimated at 50% to 66 2/3%) in Classes II through IV of Appendices A and B.

These prices apply to the European market, which because of the high fuel costs in general is higher-priced than the U.S. (charges against U.S. suppliers of "undercutting" Europe have been made).

In fact, General Refractories President J. Hartshorn reports that it is "cheaper" for American buyers to purchase brine-grade Periclase directly from Martin-Marietta in Manistee, Michigan than to import comparable synthetic material from Europe. Even the less expensive natural Magnesite comes out more expensive from Europe, he explains.

To throw more light on this matter of competetive pricing, it is also known that such European suppliers as Sardamag and Premiere Periclase can land high-quality Periclase in Rotterdam at a figure of $420 C.I.F. One supplier (suspected to be Premiere Periclase, which is known to be in trouble) is reported by RADEX as "bargaining" for sales, offering prices in Europe sufficient only to recover costs. In this connection, both Brazil and North Korea are said to practice price dumping on a periodic basis, offering material at less than $150 per MT in Rotterdam ("not brine quality, to be sure"). Brazilian exporters are reported as being eligible for a 40% refund from their government in such transactions.

One must also consider the fact that furnace maintenance may be routinely accomplished with low-grade fettling materials selling at $220 per MT or less. These may be reject materials from higher-grade production runs, in the case of

brine or sea water sources, or simply natural Magnesite. In such cases, a lower price more than compensates for a lower Magnesium Oxide content. Such materials are sprayed by a gunnite process into the hot furnace (without shutdown) and become very cost-effective compared to high price, high purity bricks. Likewise, in the caustic-burn grades, such off-grade materials find a ready market in fertilizer and other bulk uses.

ALTERNATIVE PRODUCT OUTLETS NOT ATTRACTIVE

Since Magnesium Oxide suffers from an oversupply situation in its main industrial outlet, the steel industry, are there other end users which offer any promise to a new entrant in the business? The first outlet which may come to mind is another large user of refractories, namely the cement industry. Unfortunately a relatively small amount of Periclase is utilized, normally in the form of Mag-Chrome bricks with only 0.4-0.5 pound MgO per ton cement. This is considerably less than in premium grade refractory brick steel. Furthermore, almost any grade of Periclase will do, and high purity material is unnecessary since furnaces operate at lower temperatures than in steel making. One of the significant European brick makers for cement kilns is Refratechnic of Gotting, Germany, which uses no high-grade Magnesium Oxide at all.

Clearly, there is a world oversupply in refractory or dead-burned grades of Magnesium Oxide, and the steel end use market is declining. The opposite may be said for caustic or light-burn material. Here new markets are opening up and a growth rate in the order of 20% applies, for such varied uses as cattle feeds, fertilizers, fuel additives, synthetic wall board, pulp and paper whitener, flooring cement, neoprene manufacture, soil conditioners, welding rods and even the heating elements in the kitchen stove.

Unfortunately, there are some serious drawbacks to this business. To begin with, according to Dow Chemical, the 1975 total demand for caustic grades amounted to 120,000 tons per year with an available supply of 190,000 tons. This will grow in 1981 to an estimated 200,000 tons, but the corresponding caustic supply will have grown to 280,000 tons. Some 10% of this material commands premium prices, in excess of Dead Sea Periclase material and up to $1,000 per ton. However, 80 to 90% of the volume sells typically at $40 per ton for cattle feed, fertilizers and flooring cement and is supplied by waste materials from such companies as General Refractories.

Termed an "odd lot" business, manufacture of chemical grade Magnesium Oxide also involves certain hazards and more technology than the Periclase business. A particular hazard requires critical quality control, where human health foods or animal feeds are concerned. Thus, Michigan Chemical is said to have gone out of this business, following a public reaction to killing of cattle, alledgedly caused by its caustic-grade Magnesium Oxide. For agricultural purposes, Dolomite is a cheaper substitute, known in the trade as "Do-Lime" or "Ag-Limestone"

The caustic Magnesium Oxide business is very fragmented, seldom involves long runs, and requires extremely close quality control for any chemical as well as food/feed uses. It is considered largely "locked-up" by chemical specialty manufacturers. Above all, this is definitely not a business which justifies building a separate plant in order to satisfy some part of the market.

On the other hand, when treated as a by-product of Periclase manufacture,

those existing plants with a sunk-cost (partly depreciated) investment have an obvious advantage in switching into caustic grades. One of the early companies to do this was Martin-Marietta, the largest U.S. producer. Martin in recent years installed new hearth furnaces at Manistee, Michigan for an additional 50,000 to 70,000 tons per year capacity in caustic grades. Other Periclase producers can (and will) switch to caustic grades, assuming Periclase demand remains less than supply, especially as new plants (e.g., Billiton) come on stream in Europe (see "Dark Horse in the Periclase Picture").

There is one particular application of caustic Magnesia which at least deserves passing mention, lest it build false hopes. This is the use of a highly reactive, light-burn grade of Magnesium Oxide to adsorb or scrub Sulfur Dioxide (SO_2) from coal gas stacks. For this purpose, Philadelphia Electric Company--the chief experimenter in this technology--was checked together with its architect-engineer adviser, United Engineers of Philadelphia.

While Philadelphia Electric is deeply involved with this technology, operating 3 coal-fired units (800 - 850 MW) and scrubbing output with caustic Magnesia, it appears that EPA is the main support behind this effort. Joseph Kowalski, Engineer-in-charge of this project points out that utilities with limited land are the principal candidates, since one can do the same thing with ordinary Limestone, providing large areas of land are available for sludge disposal. "The economics are a toss-up, otherwise", states Kowalski. He mentions also Boston Edison and Potomac Electric in Maryland/Virginia which previously investigated but dropped this technology, plus two utilities in Japan that are apparently still studying the proposition. Others are merely watching from the sidelines, not wanting to be "first", he states.

A definitive input was received by interviewing Philadelphia Electric's engineer consultant, Henry Bove of United Engineers, who advised that 35 U.S. companies are presently considering SO_2 scrubbing, but only 5 are located in heavy metropolitan areas where land is limited. Even those companies which have a definite need will utilize but a relatively small amount (5,000 to 10,000 tons per year) of Magnesia. This to make-up losses from the process, since the MgO is regenerated during the recovery process. A further disadvantage is the necessity to find a market for magnesium salts regenerated during the recovery process.

Additionally, the Stack Gas Studies Unit of Tennessee Valley Authority (TVA) in Alabama was interviewed, since they too have tried this technology. TVA cancelled its plans to build a 150 MW unit at Johnsonville, not because the technology would not work, but because the use of low-Sulfur coal instead was a "cheaper way to meet EPA compliance regulations". TVA technicians see a low rate of growth for this technology in the U.S., principally because of the great reluctance of large coal utilities to get involved in producing and selling chemicals (in this case, Sulfuric Acid). Even when chemical companies have offered to take over chemical recovery operations, utilities are still reluctant. A "very conservative industry", comments Gerald McGlamery of TVA's Stack Gas Studies Unit. Even lacking adequate land for disposing of large process wastes from use of Limestone (instead of Magnesium Oxide), most utilities are so far content to "struggle" with this approach, states McGlamery.

In other words, this is an intriguing outlet for Magnesium Oxide, but a small one only. In the U.S., this market is more than fully covered by Martin-Marietta in Michigan and Basic Industries in Florida, Nevada and Ohio. Furthermore, Harbison-Walker reports it looked at this technology in 1969, and found the return on investment to be insufficient to justify new equipment to make the Magnesium Oxide needed by users of coal gas scrubbing. Such equipment tends to be expensive, since the Magnesium Oxide grade needed is "superfine" and very hot.

TUNISIA ENERGY SITUATION

Periclase has been described as "stored energy", and indeed energy accounts for approximately one-half of F.O.B. plant costs, for operations buying O.P.E.C. fuel oil. This cost amounts to over $100 per ton Magnesium Oxide in some bad locations, corresponding to an energy cost of $5 to $6 per million Btu. Certain of these high fuel cost operators are reported being forced out of the business.

In contrast, U.S. operators are generally faced with energy costs in the range of $3.50 to 4.00 per million Btu. At 20 to 25 million Btu per ton of Periclase product, this is equivalent to $70 to 100 per ton of product for fuel alone. High, but not as bad as European energy costs. Thus, Steetley Minerals is already paying $6 per million Btu for fuel to fire its rotary calciners (inspected by author). Furthermore, recently reported U.S. natural gas resources show the total reserves to be greater than previously recognized. Thus, U.S. energy costs could become even cheaper, relative to high energy cost areas.

In the light of these conditions, how does Tunisia fare with respect to energy costs? For the moment, rather well, with calculated cost of fuel oil in the range of $45 to 55 per ton dead-burned product (Kaiser, for comparison, assumed $61 per ton). These figures are based on fuel oil, from such fields as the El Borma in Southern Tunisia. What is the situation with respect to natural gas? Here the news is not encouraging. A recent report (May 1981) indicates that gas from the Algeria to Italy pipeline (on which Tunisia collects royalties in the form of gas) has been raised in price from $2.00 to $6.00 per million Btu. Even at a royalty net cost of 2/3, this still amounts to $4.00 per million Btu.

From a long-range viewpoint, the Tunisian energy picture is far less than optimistic. Thus, in a recent communique from the American Embassy in Tunisia, (Tunis 2624 dated 7 April 1981), it was confirmed that Tunisian oil production is leveling off while consumption continues to rise at rates approaching 20 per cent per year (in author's interview with Youssef Bahiz, Assistant to Director of Energy, an 11-13% growth in total energy requirements in the 1970-80 decade was reported). Further, "barring any major new petroleum discoveries, the country will become a net energy importer by 1986-87". In an effort to avoid this, the Government plans to invest approximately $3 billion in energy-related projects during the Sixth Development Plan (1982-87).

In this planning, the Government has decided to take the Miskar offshore natural gas field project off the shelf for examination, and seriously to consider importing large quantities of coal for its upcoming electric power plants. However, Miskar is a high-cost project ($600-700 million) with technical problems. Further information is available on request.

Furthermore, as related to author and American Embassy officials by President Director General Moncef Ben Abdallah of L'Agence de Promotion des Investissements, Tunisia would restrict allocation of Miskar natural gas (if developed) to only 1/3 for petrochemicals and other chemicals, reserving 2/3 for electrical power generation. Trends in general do not bode well for an energy-intensive Periclase plant.

MARKETING ORGANIZATION KEY CONSIDERATION

One of the most important problems for a new manufacturer of Periclase is the early arrangement for firm marketing relationships. Here the word "relationships" takes on a special meaning, beyone the ordinary concepts of marketing channels, distributors and end users. In the European market particularly, the presence of strongly integrated cartels must be recognized. Thus, Premiere Periclase admits that it would find marketing "virtually impossible" without its tie-in to G.R. Stein, the large European refractory brickmaker which owns 49% of Premiere.

To illustrate further the so-called "incestuous" relationship of European companies in the Steel-Brickmaker-Periclase trilogy, consider the case of COGEMA of Sicily and SARDAMAG of Sardinia. These sea water Magnesium Oxide producers are part of an operating cartel which includes Steetley Minerals (UK), Veitscher (Austria), Didier (W. Germany), plus Sirma and Sanac of Italy. In turn, Sanac is related to Fiat and Teksit (steel producers in Italy) and Sirma is a family member of Finsider Steel in Italy. Didier is related to the huge Krup iron and steel organization in W. Germany and Sveitscher is allied with Deniang Steel in France.

In general, these firms will cooperate to utilize their own capacity, before resorting to buying any outside raw materials. "To sell to many of these companies is virtually impossible", states Paddy Dougherty, General Manager of Premiere Periclase (who clearly has tried every possibility, with only marginal success). Nor can an advantage be assumed for a possibly purer Magnesium Oxide from Tunisia, since (according to Kaiser's Richard Wilder), Sardinian Periclase is among the highest quality products in the world.

It was recommended earlier by Kaiser Engineers to the Government of Tunisia that it consider a working arrangement with a producer such as Steetley Minerals of England. In view of the above observations, this is wise counsel, if Tunisia desires to pursue this project despite all obstacles. As a matter of fact, author has received a communication from Steetley inquiring as to status of project and desiring to be placed in touch with the Government of Tunisia for purposes of exploring mutual interests.

A further suggestion was made by Kaiser Aluminum Consultant Ore Olsen, that Tunisia seek help from Arab colleagues in guaranteeing markets for export-grade Periclase in neighboring steel industries. This suggestion seems problematic, since each Arab country can be expected to import refractories of the highest purity available at lowest cost, if indeed it has a steel industry at all. Added to this is the fact that certain other Arab countries (Jordan, Libya, Algeria and Egypt among them) have potential projects to mine their own Magnesium sources.

PROSPECTS FOR U.S. EQUIPMENT SALES

Builders of a new Magnesium Oxide plant could outfit completely--or not at all--with U.S. equipment. In other words, while all requisite equipment can be made in the United States, there is an "analog" for every such piece of equipment manufactured someplace in Europe or Japan. No piece of equipment must be purchased in the U.S., and negotiation is the general rule. In this respect, Germany, France, England, Finland and Japan are prominent competitors.

It is true that the U.S. has historically led the way in process design of certain equipment and processes, notably the Herreshoff rotary kiln, the Nicholas shaft furnace, the Komarek briquetting presses and Eimco (wet-end) process design. However, this expertise is generally no longer patented, and comparable equipment is available much closer to Tunisia.

A case in point is the German Hutt or Koppers briquetting presses, used to densify the Magnesium Oxide before final firing to Periclase. Magnesia International (Billiton) chose this equipment over U.S. machines for its new plant near Gronigen, Netherlands, partly for the "good guarantees" and again for proximity to German test facilities and maintenance service. On the other hand, the oldest plant in Europe, Steetley Minerals in Hartlepool, England, chose U.S.-made Bepex briquetting machines. However, this equipment is the only American equipment present and a small minority of total equipment in that large plant (Exhibit 3).

The one piece of equipment which seems uniquely American is the Nichols shaft furnace, used in final firing of the Periclase. This is considered the "Cadillac" of the trade, along with the Hereshoff multiple-hearth furnace used in initial firing of this material. Until recently, these devices were made under license, such as by Pacific Foundry in Milan, Italy or by Simon Carves in England or Sim-Chem also in England. However, with expiration of the original Nichols license, these machines are now freely copied. More recently, a new competitor to Nichols, Marcus-Nell of New York (formed by 13 ex-Nichols employees) has joined forces with Refractories Consulting & Engineering GmbH (RCE) of Randenthein, Austria. This group was awarded the prime Billiton job in Gronigen, Netherlands to design and build these same furnaces. Of course, a portion of these funds will be retained by an American firm, Marcus-Nell.

On the other hand, we have the report that Premiere Periclase of Drogheda, Ireland, used Simon Carves to supply certain hearth furnaces and ended up with "nothing but trouble". Premiere is reported by one prominent consultant (who has himself built several Magnesium Oxide plants) as wishing it had gone to Nichols and Envirotech in the first place.

So much for the "hot-end" of the Periclase plant. When it comes to the wet-end, the American firm Eimco (Envirotech) enjoys a premier reputation in this field. Nevertheless, this technology is not patented, and Eimco maintains its position by offering to guarantee results of its process design, provided customers agree to purchase Eimco equipment. While U.S. technology may here be considered standard-setting, the fact is that wet-end equipment from European sources is conceded to be cheaper and generally of equal quality

and availability, and often on better terms.

To illustrate his opinion that Tunisians would buy the bulk of their equipment in Europe, President John Hartshorn of General Refractories in Philadelphia refers to the recent offer of Germans to finance 100% of a $100 million Chinese plant at 7% interest, providing German equipment is used. In general, he finds Europeans more aggressive in offering favorable financing terms and enjoying the support of their respective governments in closing such deals. Hartshorn estimates 90% of equipment for a Magnesium Oxide plant would be purchased by Tunisians from Europe. Of course, General Refractories cannot be considered as entirely unbiased, since Hartshorn is also an officer of Oesterreichisch-Amerikanische Magnesit, A.G. of which R.C.E. is a subsidiary engineering company. Nevertheless, his observation may be regarded as generally true, based on other independent information cited elsewhere in this report.

Let us now be specific in investigating the possible pay-back of a T.D.P. investment in the range $300,000 to $500,000, using actual results from three actual Magnesium Oxide plants in Europe. TDP Selection Criterion number 5 states: "Projects for priority consideration must evidence likely minimum procurement from U.S. sources of 50 to 100 times the TDP expenditure within three to five years". Kaiser has requested consideration of $310,000 for wet-end pilot plant equipment only, but as a result of his investigation, author is convinced ultimate cost would be closer to $500,000, and Government of Tunisia would ultimately be coming back to ask for this amount. Even using the lower figure, what would the multiplier (a form of payout calculation) be for Magnesia International (Netherlands), Steetley Minerals (England) and Premiere Periclase (Ireland)? This is answered specifically in Exhibit 3.

Actual inspection by author of these three plant facilities, together with detailed conversations with operating management, revealed the presence of the specific U.S. equipment detailed in Exhibit 3. Where a license applies, rather than outright purchase, a royalty rate of 10% is assumed in computing the appropriate multiplier. Results show an equipment cost per plant ranging from $500,000 (a multiplier of only 1.8 times TDP investment) to a maximum of $4,700,000, a mere 15 times multiplier based on TDP investment of $310,000 (or a 9.4 multiplier based on a more realistic $500,000 investment).

Clearly, then, it must be concluded that U.S. sources are far from proprietary and exclusive in their hold on this Tunisian market and the possible payout is markedly small and below TDP standards of minimum procurement size.

It will be remembered that these figures are based on gross sales to U.S. suppliers, and not profits. Hence a multiplier of 15, for example, would only barely repay the original TDP seed money investment, in terms of a net profit margin of (say) 10 per cent. Of course, this is why the criterion payout is set at 50 to 100 times, and even this provides but a nominal pay back in terms of profits to U.S. businesses (and thus to TDP).

EXHIBIT 3

RETURN ON T.D.P. INVESTMENT

(Criterion #5)

A. Magnesia International (Gronigen, Netherlands)

		License @ 10%
Multiple-Hearth Furnace	$3 Million	$0.3 Million
Shaft Furnace	3	3.0
Cottrell Precipitators	2	0.2
Eimco Filter	7.5	0.8
Foxboro Instrumentation (1/4 to 1/3)	11	0.4
		$4.7 Million

$\frac{4,700,000}{310,000}$ = 15.2 Multiplier on TDP investment*

($\frac{4,700,000}{500,000}$ = 9.4 actual)

B. Steetley Minerals (Hartlepool, England)

10 MS-150 Bepex briquetting machines @ $150,000 $1.5 Million

$\frac{1,500,000}{310,000}$ = 4.8 Multiplier on TDP investment*

C. Premiere Periclase (Drogheda, Ireland)

Envirotech process technology $200,000-400,000 total 100,000-200,000 est. U.S. Share	$0.10 - 0.20 Million
Eagle-Iron quarry equipment	0.40
	$0.50 - 0.60 Million

$\frac{550,000}{310,000}$ = 1.8 Multiplier on TDP investment*

*Criterion: 50 - 100 times TDP investment minimum

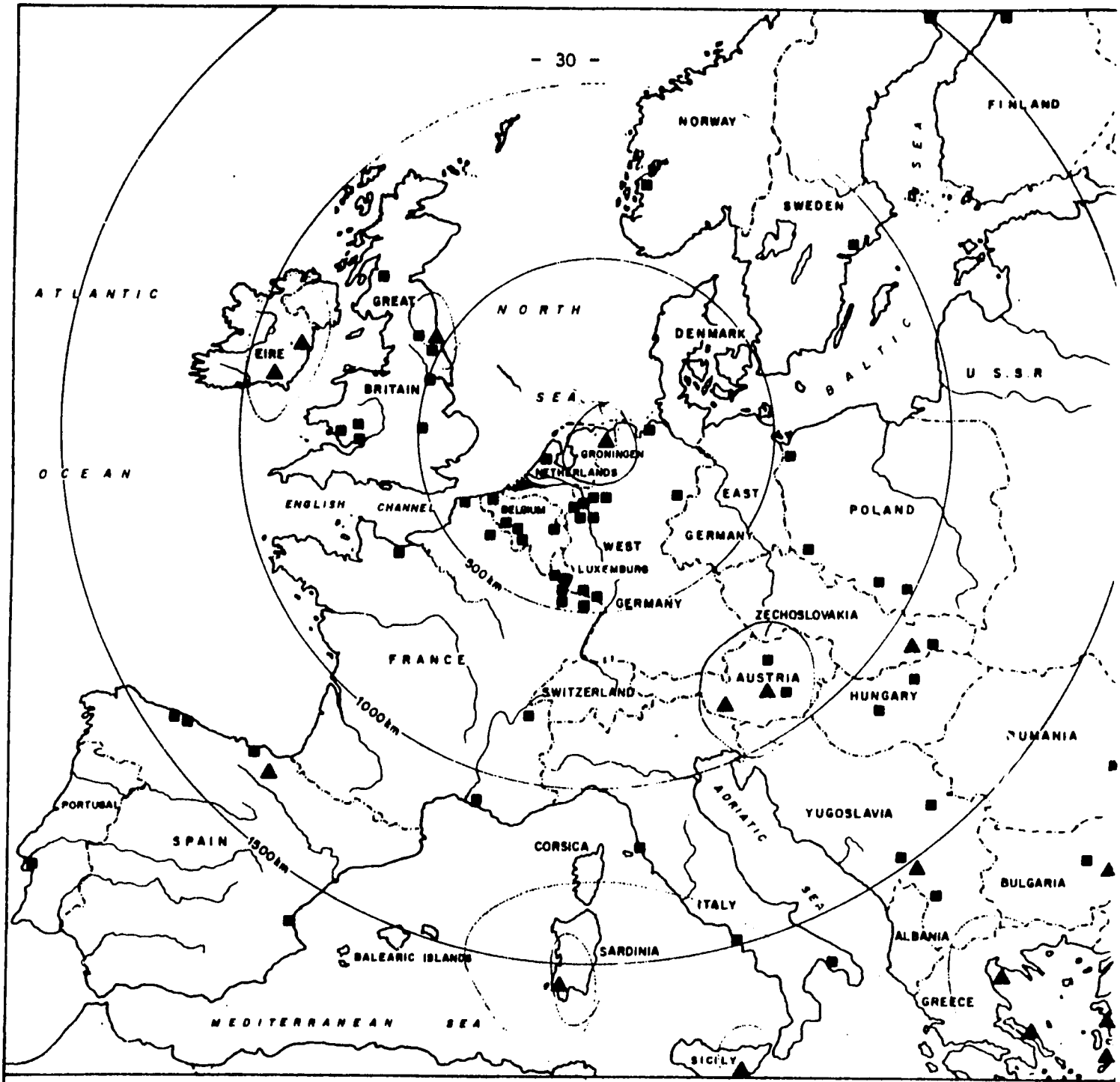
DARK HORSE IN THE PERICLASE PICTURE

Threatening to up-stage all other competitors in the Western European market is the new Magnesia International Plant (Billiton International Metals), now 60 per cent complete in Groningen, The Netherlands. The Province of Groningen sits astride one of the largest oil fields in Europe, made even more important by the discovery of natural gas in the offshore North Sea waters. The significance of this, of course, is that energy costs normally account for some 50% of Periclase costs, and an important cost advantage will therefore accrue to the Billiton product. Dutch Shell, which owns Billiton Metals, will mine this key gas supply together with ESSO--both major energy companies.

Equally important is what is perhaps the most strategic location for a Periclase plant in all of Europe. As illustrated by the accompanying map (Exhibit 4), within a radius of 500 kilometers (300 miles) lies 80% of the West European industrial market. Examination of the actual plant at Groningen has shown not only the most modern equipment, but a canal and rail/lorry system that will be able to provide product delivery at an advantageous cost compared to many competitors, certainly to any plant in Tunisia. Thus, in the opinion of General Director Karl Leitner of Osterreichisch-Amerikanische Magnesit A.G. (RADEX), if Billiton and Tunisia produced the same quality of material, Tunisia would stand no chance except in Italy and Spain, with Billiton controlling the West Europe market. This assumes that fuel costs would be comparable, which is questionable at this point. (See "Tunisia Energy Situation").

Interviewing Vice President of Billiton International Metals, Richard J. DeVries in Amsterdam, has revealed additional facts on which this company bases its confidence. To begin with, Billiton has been in laboratory and pilot plant development of this addition to its product line since 1975, utilizing 25 people ("the majority in refractories"). DeVries acknowledges the use of pilot plants both Harbison-Walker and General Refractories/R.C.E. in Randenthein, Austria to supply what they consider to be the latest in hot-end technology and equipment. Billiton conducted its "sixth campaign" in January of this year with its pilot plant, producing another 20 tons of Periclase for customer trials. It is clear from personal inspection of plant by author that only first-rate equipment has been used, including full central control; in fact, if anything the plant might be considered somewhat "gold plated" in its refinement. This is evidenced in part by the fact that an original projected investment with Fluor Engineers in the neighborhood of $132 million has already grown to $140 million, and plant completion start-up is not scheduled before Summer of 1981. Some industry authorities (as Stu Spater of Nichols Engineering) consider this "way higher than anything envisioned" by his company for this size plant.

The strategy of Billiton is plain enough, and not unlike that which the Government of Tunisia officials hope for. Thus, Billiton sees the industry-wide market as shrinking and hopes to compensate for this by setting a "different standard" of quality and shooting for the highest quality end of the market spectrum. Evidence that they can very possibly accomplish this is provided by



LEGEND

■ STEEL PRODUCTION PLANT

▲ MAGNESIA PRODUCTION PLANT

Exhibit 4

BILLITON INTERNATIONAL METALS B.V.	
The Hague	MTRF

EUROPE

CRUDE STEEL AND MAGNESIA PRODUCTION PLANTS

Author	Date	December 1977
Report No.	Date	8673

several coincident facts. First, the industry product compilation (Appendices A and B) places Billiton tentatively in the highest or next-to-highest categories, equal or almost so with Dead Sea Periclase and Ube of Japan. Secondly, by the rating of its competitor RADEX, and based upon published pilot results, Billiton product should place between that of Dead Sea Periclase ("not far behind") and those of COGEMA and SARDSMAG, all known high-quality sources. Thirdly, these prior facts are true only because Billiton has known access to particularly pure raw material sources.

On the other side of the ledger is wide disbelief in industry circles that this plant could possibly prove economical. Dow Chemical is particularly critical, stating that even at $500 per ton for product, no one could afford to build a Billiton-type plant. To prove its charge of "a classic example of bad investment", Dow notes that just the debt service on a 100,000 TPY plant at $1,500 per ton capital investment would be $300 per ton, exclusive of labor and especially energy (normally 50% of product by itself). "Some deal is inevitable", Dow personnel noted in author's interview.

This question is easier to understand after interview with DeVries of Billiton, who explained first that his company expects to achieve 50% additional production (150,000 instead of 100,000 TPY) after debottlenecking plant. This, he feels, "far outweighs the high costs" of construction, especially when taken in conjunction with Billiton's plans to offer a top-grade product and its particular freight and fuel advantage. In addition, DeVries implied (as suspected) that as part of Dutch Shell, Billiton will enjoy a "favorable financing package". To supplement its "performance grade" Periclase product ("equivalent to Dead Sea quality") Billiton also plans to offer a complete package of related refractories to the brick industry, consisting of refactory Chromite, Graphite plus Aluminum Oxide.

Time will tell if this self-appraisal comes true, but in any case the presence of this giant in the heart of W. Europe presents a formidable obstacle to new entrant in the Periclase business.

KAISER PILOT PLANT: OBSERVATIONS

Initial contacts with Kaiser Engineers' Richard F. Wilder, Tunisia Project Director, have revealed a professional engineering approach and reasonable cost estimates, subject to some reservations. Thus, Kaiser's estimate of $310,000 for a wet-end pilot plant of 1,000 kg/day capacity (1 MT/day) is not unreasonable, considering that $170,000 additional (in Tunisian Dinars) plus certain other operating expenses are assumed furnished by the Government of Tunisia.

On the other hand, a total capital cost of $113 million may very possibly be too low for the total plant, especially in a remote environment, when compared to certain plants in Europe. Although not strictly comparable, we note that the 100,000 MTY Billiton plant in Gronigen, Netherlands--originally estimated to cost $132 million by Contractor Fluor--has already reached $140 million at the 60% completion mark.

If a pilot plant could be considered a wise investment in the first place, Kaiser is prudent in suggesting this be limited to a wet-end plant, reserving testing of the intermediate Magnesium Hydroxide product in a foreign hot-end pilot plant. For this purpose, Kaiser has properly considered Nichols Engineering of Princeton, New Jersey. In this vein, Harbison-Walker will rent its hot-end pilot plant in the U.S. for selected projects, as it did for the Billiton plant in The Netherlands. A suitable business arrangement with Harbison-Walker would be a presumed necessity.

Another possibility is the joint venture of Marcus & Nell of New York with Refractories Consulting & Engineering GmbH (RCE) of Randenthein, Austria. RCE is a separate small company organized as the engineering arm of Osterreichisch-Amerikanische Magnesit AG in Randenthein, and both are controlled by Philadelphia-based General Refractories. This firm was responsible for supplying basic engineering on the Dead Sea Periclase plant plus the calcining furnaces and shaft kilns (hot-end) of the Billiton plant in the Netherlands. RCE operates a $400,000 hot-end pilot plant at Randenthein which may be utilized in test programs, although it is presumed some participation in the basic engineering study (or a joint venture participation) would be required.

In any case, a pilot plant may not be said to be a prerequisite to the pre-feasibility study conducted by Kaiser for the Tunisian Government. Thus, Wilder readily admits that Kaiser desires this pilot plant to provide a head-start in possible full plant construction, which project they definitely hope to win if pilot plant tests were successful. It is quite true that proof of product quality is a prerequisite to winning certain Periclase business, but not to the completion of a pre-feasibility study in which revenues from the possible market for a product (of any assumed quality) are compared to capital and operating costs of necessary investment. In other words, one doesn't necessarily have to prove product quality if it is known in advance that there is little chance of capturing a significant market for even the highest grade of Periclase final product.

RAW MATERIALS REASONABLE

In examining the analyses supplied by Kaiser Engineers for Zarzis brines and M'Dou Limestone, it is evident that these would constitute a reasonable starting point for production, on a purely technical basis. Magnesium content is reasonably high, Calcium content is desirably low. Sulfate content is likewise comfortably low, thus avoiding the necessity of Sodium Sulfate separation. Chlorine content is rather high, which could lead to problems in disposal of residual brines. Specific gravity of brines is high enough (1.24 to 1.25) to constitute a possible problem, unless adequate water is available to dilute this brine before processing. Potash content is low for economical production of this material, but since this is only a by-product the problem may not be significant.

As for the M'Dou Limestone (particularly sample location "C") this is relatively pure, although comparatively high in the R_2O_3 group (Fe_2O_3, Al_2O_3, etc.). It is also rather high in SiO_2, although probably not high enough to require beneficiation. Another critical compound, B_2O_3, is said to be low, which is reasonable for a brine source as compared to sea water. Thus, in the case of Harbison-Walker in Ludington, Michigan, a B_2O_3 content of 0.03% or less is allowable, and Kaiser Engineers indicate this requirement is more than met. Competitors such as Billiton, Mexico and the Dead Sea all boast much lower B_2O_3.

Tunisia has no apparent source of Dolomite (a combined Limestone and Magnesium Carbonate), which would make for decided economics in processing. Thus, introducing Magnesium in the form of "Do-lime" reduces the cost of production, in terms of fuel requirements(one-half as much using Limestone) and provides faster settling and filtering capacilities. Kaiser advises that tests at El Hamma have established local Dolomite as unacceptable for this purpose, based on high SiO_2 content.

By comparison, Dolomites used by numerous U.S. producers are reputed to be among the purest in the world, with "ultra-low" SiO_2. In this respect, Tunisia would be like Steetley Minerals, which is forced to use Limestone in order to make high-purity product, since its Dolomite source is too high in Fe_2O_3 and possibly in SiO_2.

JOINT VENTURE OR TECHNICAL ASSISTANCE PROSPECTS

Assuming that the Government of Tunisia might wish to pursue this project, without official U.S. Government help, is there any hope from the American private sector? This could presumably take the form of either technical assistance on a fee-paid basis or possibly a joint venture.

In the case of technical assistance--or technology licensing--this is a common practice. Thus, General Refractories technical assistance to Dead Sea Periclase and Harbison-Walker plus Nichols Engineering assistance to Billiton Minerals are cases in point. In the case of Tunisia, Harbison-Walker states that while rarely interested in joint ventures, "we are always interested in licensing". Basic Chemicals of Cleveland expresses "no keen interest" in such a joint venture, but states it "could be interested" in technical assistance. Dow Chemical has at least two successful joint ventures to its credit (Dow Corning and Asahi); however, Dow has taken a stand against the advisability of the Tunisian project and U.S. participation in same.

Nichols Engineering, well-known in Magnesium Oxide industry for its shaft furnace and Hereshoff multiple-hearth furnace, is willing to lease pilot plant equipment and engineers on a time basis to run hot-end tests on product Magnesium Hydroxide and to interpret the resulting data. As observed previously, General Refractories, and its R.C.E. subsidiary in Randenthein, Austria (a competitor to Nichols) are likewise willing to consider licensing of technology on an up-front, fee-paid basis, although President John Hartshorn has advised against the Tunisian venture (c.f., "Widespread Oversupply of Periclase"). In the case of Billiton and North Korea, General Refractories supplied aid on a straight-fee basis. A more favorable arrangement, from Tunisia's standpoint, would be to negotiate technical assistance on the basis of offering a discount on purchases of Periclase, as did Dead Sea Periclase to General.

One company in author's survey did express interest in a possible joint venture with Tunisia. This is North American Refractories (NARCO) of Cleveland, Ohio, a part of Allied Chemical Company. Known in investment circles as "Allied Oil", because of its oil and gas profits, Allied Chemical is actively looking for investment projects with good long-range prospects. A cable (State 090616) dated 10 April 1981 was dispatched to the American Embassy, Tunis describing this interest. Executive Vice President Ed Wright of NARCO explains that his company actively seeks sources of high-quality Magnesium Oxide at good prices, and that its past success has been due in part to locating these.

One might ask why Kaiser Engineering and related companies would not be adequate to meet all these needs. While it is not known to author the interest of Kaiser in investing its own funds in a Tunisian project, it is apparent that the industry is not generally of the opinion that Kaiser Engineering can do the technical job alone. One major Periclase producer describes Kaiser as able primarily to build the plant, but adds "they will need help". Another major acknowledges Kaiser's expertise in sea water extraction and scrubbers for dust collection, but questions adequacy for entire operation. "We would want to examine and critique this technology before using, if a joint venture were involved".

At an earlier point in the project, Kaiser Engineers suggested to the Government of Tunisia the desirability of finding a cooperating European partner, and mentioned Steetley Minerals of Hartlepool as one prospect. As a matter of fact, following author's interview with Steetley's Chairman and Managing Director T.W. Lythe, a letter has been received inquiring as to AID's opinion of this project and (if likely to proceed) "how we may become involved". This contact would be well worth following up by Tunisia, if for nothing more than to learn more about how Periclase is made by one of the oldest firms in this business.

To repeat an earlier observation, both German and Japanese manufacturers have been known to give extensive credits in financing certain desired new plant construction and equipment. In some cases, such firms may even be willing to take a percentage of product (possibly including Periclase) as partial repayment of loans advanced. Of course, Japan is itself a major world producer of Periclase and East Germany is reported undertaking production from waste potash brines.

* * *

Appendix A

CLASSIFICATION OF PERICLASE GRADES

In order to differentiate the various grades of Periclase and/or Magnesite available, six groupings may be identified:

	COMMENTS
CLASS I Ultra High Purity $SiO_2 < 0.30\%$ $MgO > 98\%$	"Hard to justify cost"
CLASS II High CaO/SiO_2 Ratio $> 2:1$ $MgO > 96.0\%$ $B_2O_3 < 0.03\%$	High hot-strength brick
CLASS III CaO/SiO_2 Ratio $> 2.0\%$ $B_2O_3 > 0.03\%$ $MgO > 96\%$	Pitch or tar-bonded brick (carbon bond) (not high hot-strength).
CLASS IV CaO/SiO_2 Ratio 1:1 $B_2O_3 > 0.10\%$ $MgO > 96.5\%$	Mag-chrome, direct-bonded 98% MgO common BO_3 .15% typical Less costly. Higher thermal shock. Used in cement, glass, open-hearth.
CLASS V $B_2O_3 < 0.1\%$ $MgO < 96.5\%$	Displaced old silica brick practice.
CLASS VI $B_2O_3 > 0.1\%$ $MgO < 96.5\%$	88-92% common. Gunnite use.

Appendix B

CHEMICAL ANALYSES OF COMMERCIAL PERICLASE PRODUCTS

	QUALITY (typical)	MgO	CaO	SiO_2	Al_2O_3	Fe_2O_3	B_2O_3	B. D.
CLASS I								
Dead Sea Periclase Ltd.	Gem 903	99.2%	0.55%	0.06%	0.03%	0.05%	<0.01%	3.47
Industrias Penoles Quimica Del Rey S.A.	RY-98 std.	98.29%	1.20%	0.20%	0.20%	0.10%	0.01%	3.35 - 3.40
	RY-98 BC	98.69%	0.90%	0.20%	0.20%	0.10%	0.01%	3.35 - 3.40
Ube Chemical Industries	99S	99.2%	0.40-0.50%	0.10-0.30%	0.04-0.06%	0.04-0.06%	0.01-0.03%	3.29 - 3.35
Kaiser	HP	98.06%	0.68%	0.30%	0.21%	0.30%	0.23%	
Asahi	SSS-LB	98.4%	1.00%	0.30%	0.06%	0.07%	0.02%	3.30 - 3.35
Billiton		98.0%	0.65%	0.20%	0.15%	0.50%	0.02%	3.45
CLASS II								
Martin Marietta	96 (HD)	96.3%	2.20%	0.55%	0.20%	0.30%	0.02%	3.44 - 3.43
Martin Marietta	96 (4:1)	96.3%	2.20%	0.55%	0.20%	0.30%	0.02%	3.36 - 3.40
Harbison Walker	96 A	96.6%	2.3%	0.7%	0.20%	0.30%	0.02%	3.36 - 3.41
Fimisco	MAGFLOT A	96.4%	2.3%	0.7%	0.12%	0.38%	<0.002%	3.35 - 3.40
Fimisco	MAGFLOT AB	96.0%	3.0%	1.00%	0.12%	0.68%	<0.002%	3.40
Cogema	-	-	-	-	-	-	-	-
Premiere Periclase	96 HDLB	96.8%	2.0-2.5%	0.30%	0.10%	0.15%	0.05%	3.42
Sardamag	-	-	-	-	-	-	-	-
CLASS III								
Basic	DB 98 RK	96.5%	1.95%	0.77%	0.35%	0.35%	0.5-0.6%	3.42
A.P. Green	97 (3:1)	-	-	-	-	-	-	-
Ube	97 (HD)	97.0-97.5%	1.50-2.0%	0.60-0.80%	0.05-0.10%	0.05-0.10%	0.08-0.15%	3.40 - 3.45
Asahi	SSS	98.6%	0.1-1.2%	0.2-0.25%	0.07-0.10%	0.07-0.10%	0.06-0.07%	3.30 - 3.35
Asahi	ASP	97.8%	0.9%	0.75%	0.18%	0.22%	0.10%	3.25
Ube	Green	98.0-98.5%	0.80-1.0%	0.20-0.40%	0.05-0.10%	0.05-0.10%	0.40-0.55%	3.25 - 3.35
CLASS IV								
Martin Marietta	98 (1:1)	98.05%	0.80%	0.60%	0.25%	0.25%	0.15%	3.30 - 3.33
Ube	98	97.8-98.3%	0.80-1.00%	0.80-1.00%	0.05-0.10%	0.05-0.10%	0.05-0.15%	3.30 - 3.35
Ube	975	97.5-98.0%	0.80-1.00%	0.80-1.00%	0.05-0.15%	0.05-0.10%	0.30-0.50%	3.20 - 3.30
Harbison Walker	98	98.10%	0.52%	0.50%	0.23%	0.35%	0.15%	3.34
Sirma		97.25%	1.14%	1.32%	0.14%	0.13%	0.09%	3.34
Sardamag	11 P	98.2%	0.6%	0.6%	0.2%	0.2%	0.2%	3.35
Steetly	112P	96.5%	0.8%	0.8%	0.15%	1.3%	0.15%	3.35

	QUALITY (typical)	MgO	CaO	SiO_2	Al_2O_3	Fe_2O_3	Cr_2O_3	B_2O_3	B.D.
CLASS V									
Fimisco	E21A	94.0-95.0%	2.60%	1.50-2.00%	0.27-1.00%	0.69%		0.008%	3.45
Fimisco	E21B	92.5%	3.80%	2.65%		Al_2O_3		0.01%	3.35
Fimisco	E11E	88.5%	5.5%	5.5%	1.5-2.0%	+		0.01%	3.30
Fimisco	E21E	86%	5.5%	5.5%		Fe_2O_3		0.01%	3.30
Fimisco	MAGFLOT B	94.0%	3.6-3.9%	1.6-1.80%	0.12%	0.68%		0.01%	3.30
CLASS VI									
Harbison Walker	Cape May	92.30%	1.04%	3.18%	0.77%	0.28%		0.11%	3.30 - 3.35
Ube	95	95.0-95.50%	1.10-1.50%	2.50-3.0%	0.10-0.15%	0.10-0.15%		0.5-0.30%	3.30 - 3.40
Ube	96	96.0%	0.80-1.0%	1.80-2.30%	0.05-0.10%	0.05-0.10%		0.10-0.20%	3.2
Steetly	132	93.5%	0.8%	3.5%	0.5%	1.3%		0.15%	3.0
Steetly	122	93.7%	2.2%	2.0%	0.6%	1.3%		0.2%	3.1
Steetly	2.5	91.7%	1.7%	0.9%	0.5%	5.0%		0.2%	2.92
Magnesita S.A.	M 10	93.99%	0.54%	1.37%	0.21%	1.90%		0.21%	3.20
Magnesita S.A.	M 20	94.66%	0.37%	1.48%	0.31%	2.05%		0.31%	3.38
Magnesita S.A.	M 30	96.5%	0.46%	1.09%	0.31%	0.92%		0.31%	3.32
Cohart, Pascagoula,Miss.	H.D.	94.41%	0.89%	1.16%	1.04%	1.24%	1.19%	0.07%	3.20
Asahi	H.P.	95%	1.0%	2.7%	0.6%	0.3%			
Continental Metals Corp.	A	91.42%	1.26%	3.51%	1.54%	0.94%			
	B	89.96%	1.34%	5.83%	1.66%	1.1%			
	C	89.33%	1.87%	5.38%	1.88%	0.9%			
	D	88.27%	3.4%	3.87%	1.91%	2.12%			

Appendix C

WORLD CAPACITY FOR DEADBURNED MAGNESITE PRODUCTION 1978 BY PRODUCER

('000 M.T.)

	TOTAL	
Austria		
Veitscher Magnesitwerke AG	300	
OEAMAG	250	
		550
Eire		
Quigley Magnesite Co.	70	
		70
Greece		
Financial Mining Industrial and Shipping Corp. (Scalistiri)	250	
Macedonian Magnesite (Scalistiri)	80	
Grecian Magnesite Co.	90	
Magnomin-General Mining Co.	55	
Mining Trading & Mfg. Ltd.	50	
Magnesite Mining Industrial & Commercial Co.	85	
		610
Italy		
Sirma	60	
Sardamag SpA	120	
		180
Spain		
Magnesitas Navarras SA	110	
		110
U. K.		
Steetley	230	
		230
Canada		
Dresser Industries Canada Ltd.	60	
		60
U. S. A.		
Basic Inc. (Gabbs)	80	
Basic Inc. (Port St. Joe)	50	
A. P. Green Refractories Co.	40	
Harbison-Walker (Cape May)	100	
Harbison-Walker (Ludington)	180	
Kaiser Refractories (Moss Landing)	130	
Corchem (Discontinued)	40	
Martin Marietta Corp. (Manistee)	150	
Martin Marietta Corp. (Midland)	40	
		810

Japan		
Ube Chemical Industries Ltd.	450	
Asahi Chemical Industry Co.	265	
		715
Czechoslovakia		
Slovenska Magnesitove Zavody	250	
		250
U. S. S. R.	1,500	
Total Raw Magnesite output = 3.3 million tonnes p.a. .. probably producing about 1.4 million tonnes p.a. of deadburnt from this + 100,000 t.p.a. seawater plant at Sivash, Crimea.		1,500 1/
Yugoslavia		
Magnohrom	200	
		200
Brazil		
Magnesita SA	170	
Ceramica de Guaralhos	20	
Ceramica Sao Caetano	20	
		210
China		
Total raw magnesite output = 1 million tonnes + p.a. .. probably producing about 400,000 t.p.a. of deadburnt magnesite.	400	400 2/
India		
Salem Magnesite (Pvt.) Ltd.	25	
Dalmia Magnesite Corp.	30	
Tata Iron & Steel Co. Ltd.	9	
Almora Magnesite Ltd.	35	
		99
Turkey	200	
		200
North Korea	700	
		700
Israel		
Dead Sea Periclase Ltd.	50	
		50
Mexico		
Quimica del Mar S.A.	50	
Quimica del Rey S.A.	40	
		90
	TOTAL	6,534 3/

1/ Estimated 1,000,000 MT 1980
2/ Estimated 1,000,000 MT 1980
3/ Estimated 7,770,000 MT 1980

Appendix D

R 190605Z Mar 81
FM SECSTATE WASHDC
TO AMEMBASSY TUNIS

UNCLAS STATE 070008

SUBJECT: Magnesium Oxide Plant Visitation List

REF: TUNIS 0615

ATTENTION: A.A. Wallace, Chief, Economic Section
Pass to USDOC for CAGNE, ATTN: Holly Mak

1. As promised during final debriefing, firms and offices interviewed during investigation by Engineer Harold A. Le Sieur, DS/ENGR, are forwarded for benefit of possible visit arrangements by ONM engineer or team:

A. Europe Contacts

Brussels, Belgium Avenue Hamoir 12.14 B-1180 Brussels	International Iron and Steel Institute	D. Oscar Anderson, Chief Economist
Drogheda, Ireland Boyne Road Drogheda Co. Louth, Ireland	Premiere Periclase, Ltd.	Patrick J. Doherty, General Manager
Radenthein, Austria Postfach 21	Osterreichisch-Amerikanische Magnesit A.G.	Karl Leitner, Generaldirektor
Amsterdam, The Netherlands 19 Louis Couperusplein, 2514 HP	Magnesia International (Billiton Int'l. Metals)	Dr. Richard J. De Vries, Vice President
Hartlepool, England P.O. Box 8 Cleveland TS24 OBY	Steetley Minerals Ltd.	Trevor W. Lythe, Managing Director Noel Heasman, Development Dir.
Radenthein, Austria	Refractories Consulting Engineering, GMBH	Gunther M. Jungmeier, Managing Director

B. U.S.A. Contacts

Executive Plaza 2 Hunt Valley,, MD 21030	Martin-Marietta Corp. Refractories Div.	Robert F. Grady, III, V.P. Technology Paul E. Scheerer, Technical Director
1500 Encanto Place Walnut Creek, CA 94596	James C. Hicks, Consultant	

2401 "E" St., N.W. Room 756 Washington, D.C.	U.S. Bureau of Mines	B. Petkof Magnesium Specialist
Gateway 2 11th Floor Pittsburgh, PA Edward Einstein, Manager, Process Development Charles Van Etten, Manager, Technical Services	Harbison-Walker	Loren Duncan, V.P. Manufac. and Tech. Services
Salt Lake City, Utah	EIMCO	Robert Emmett
Muscle Shoals, Alabama	Tennessee Valley Authority	Gerald McGlamery
Philadelphia, PA	Philadelphia Electric Co.	Joseph Kowalski Engineer-in-Charge
Philadelphia, PA	United Engineers	Henry Bove Principal
Cleveland, Ohio E. 14th and Euclid Ave. Hanna Building 9th Floor	North American Refractories	Edward Wright, Exec. V.P. David Wherle Manager, Special Projects
Bela Cynwyd, PA 19004 50 Monument Dr.	General Refractories	James Hartshorn President Dr. Lawrence Le Bauer Dir. Research and Development
Bellemeade, NJ Homestead and Willow	Nichols Engineering	Stewart Spater Louis Barry
Midland, Michigan 48640 Alan Hart, Research Group Leader James Birkes, Product Sales Manager	Dow Chemical Co.	Richard J. Dolinski, Brine Business Mgr.
New York, NY 10006 33 Rector St.	Marcus-Nell Co.	David Nell
Cleveland, Ohio	Basic Refractories	Anthony Caito, Pres. Joseph Lawler, V.P. International
San Francisco, CA 94109 1000 North Point	Fred De Naestri, Consultant	
Pittsburgh, PA	Oscar Wicken, Consultant	
Oakland, CA	Kaiser Engineers and Constructors, Inc.	Richard F. Wilder Special Projects Dir.
Oakland, CA	Kaiser Aluminum	Ore Olsen, Consultant

Skokie, Illinois Old Orchard Road	Portland Cement Association	Walter Kunge Head, Research and Development
Charles Neise, Manager, Process Development Section		
1411 W. St. Andrews Midland, Michigan 48640	W.P. Schambra, Consultant	
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We trust this listing will provide valuable contacts for possible visit of GOT/ONM team, and will be happy to assist Amembassy Tunis as may be needed. By separate cable, one prospect (North American Refractories) which has some personal interest in the Zarzis Brines Project is documented for the benefit of ONM.

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