Mines Branch Information Circular IC 202

FACTORS OF PARTICULAR SIGNIFICANCE TO THE ECONOMICS OF INDUSTRIAL MINERALS

by

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ABSTRACT

Industrial minerals are to some extent unusual because they are more sensitive to certain interrelated economic factors than are other products of the mining industry. The ascertainment of markets and the cost of transporting the products to market are likely to be more decisive than the grade of the deposit in effecting its development. The large volume of material that so often must be moved, i.e. the bulkiness of a commodity, strictly limits shipping distances and therefore the areas in which deposits can be developed. The expansion of urban areas tends to interfere with the supply of the particular mineral raw materials that feed this expansion. Several other factors, some relating in a special way to processing and marketing, are of more limited importance.

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Direction des mines

Circulaire d'information IC 202

LES FACTEURS IMPORTANTS DE L'ÉCONOMIE DES MINÉRAUX INDUSTRIELS

par

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RÉSUMÉ

Les minéraux industriels sont quelque peu exceptionnels en ce qu'ils sont plus sensibles à certains facteurs économiques que d'autres produits de l'industrie minière. La décision d'exploiter un gisement peut souvent dépendre plus de la certitude de son écoulement et du coût de son transport que de sa qualité. Le volume considérable de matériaux qu'il faut fréquemment déplacer, autrement dit l'encombrement d'un produit, limite radicalement les distances de transport, et par le fait même, les régions se prêtant à l'exploitation de gisements. L'expansion des régions urbaines tend à nuire à l'approvisionnement de ces matières minérales brutes qui précisément l'alimentent. Plusieurs autres facteurs dont quelques-uns se rattachent plus spécialement au traitement et à la mise en marché, présentent une importance plus limitée.

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CONTENTS

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GENERAL STATEMENT

This circular is a revision of a paper prepared as a contribution to a course on Mineral Industry Economics conducted by the Department of Mining Engineering and Applied Geophysics of McGill University, January 9 to 21, 1967.

'Industrial minerals' is a term applied to those minerals and assemblages of minerals that are economically important because of their desirable physical or chemical properties rather than their metals or energy content. It also includes such products as cement, lime, titanium dioxide, and a small but growing number of synthetic, non-metallic minerals, such as lead zirconate-titanite and silicon carbide.

Certain industrial minerals have been important to man since he began to use tools and weapons. As recently as two generations ago, most industrial-mineral operations were small, simple and local, but growth in many segments of the industry has been remarkable, particularly since the beginning of World War II. As the operations grew, they generated the need for product specifications and for means of measuring product quality, and a trend developed to establish a few large, well-organized, well-equipped and automated operations in place of many small operations. This increasingly complex industry has contributed to the development of a host of designers, manufacturers and operators of specialized equipment for processing the minerals and characterizing the products, and, perhaps most importantly, to the growing prominence of the market researcher, without whom the industry could not function effectively. And yet there remains a common lack of appreciation and expert knowledge of many of the fundamental technical and economic aspects of industrial minerals.

In 1967, Canada produced more than 330 million short tons of industrial minerals, worth $875 million (not counting the domestic clay in $43 million worth of clay products). Sand, gravel and stone comprised about 90 per cent of this tonnage but, because of low cost, represented only about 30 per cent of the value. In most countries, industrial minerals are closely linked to domestic consumption. As a country becomes more developed and industrialized, and as its standard of living rises, its requirements for industrial minerals increase more rapidly. In Canada, the dollar value of industrial-mineral exports (perhaps 40 per cent of the total) is important, but actually the bulk of production is used at home. The industrial-mineral industry provides the cement, sand, gravel, stone, lime and gypsum plaster for all manner of construction; the raw materials for the fluxes and most of the refractories used in the metallurgical industry; the principal raw materials for glass, enamels and the multitude of other ceramic products; and the basic raw materials for inorganic chemicals and fertilizers.

The family of industrial minerals exhibits wide diversity in type of deposit, methods of mining and processing, the details of transportation and marketing, the degree and type of quality control of products, and the price (from less than $1 a ton for sand to the equivalent of several thousands of dollars a ton for high-quality muscovite sheet). Because of the diversity, many industrial-mineral deposits have their own special problems relating to development and production -- problems that often require unusual solutions.

INTRODUCTION

The evaluation of an industrial-mineral deposit is comparatively difficult. The mineral in the ground can be considered to have no value, regardless of how promising the physical aspects of the deposit are, until the making of a saleable product and the existence of a buyer have been demonstrated. Few industrial-mineral operations can be started today without technical competence and capital and a thorough understanding of the economic factors.

Industrial minerals have been classified on the basis of: a) their being true minerals, rocks or products, b) the relative importance of physical and chemical properties, and c) the relative importance of "place value", which is an indication of the significance of deposit location with respect to the market. For such industrial minerals as sand, gravel, stone, common clay and gypsum, the place value is usually of paramount importance. For such as barite, feldspar, phosphate, potash and salt, it is of lesser importance. For asbestos, graphite, sheet mica, sulphur and fluorspar, the inherent physical and/or chemical characteristics override the importance of place value.

The development of an industrial-mineral deposit may be influenced by many economic factors. Of particular significance are:

1. The dominant importance of the market and, frequently, the range and complexity of the mineral products required.

2. The necessity, in most cases, of low transportation and distribution costs.

3. The need of delivering high-bulk commodities at low unit cost.

4. The growing importance of consumer service.

Other factors of importance in a more limited way are:

5. The special features relating to processing.
6. The ability to substitute one commodity wholly or partly for another.
7. The effect of the growth of urban areas on development and expansion in the industrial-mineral industry that supplies raw materials for this growth.
8. The need for the reclamation of mined land.

These factors are by no means mutually independent and do not all apply to every industrial mineral. They are not unique to industrial minerals but tend to be more relevant to them than to metallic minerals and fuels.

ECONOMIC FACTORS

The Market

Establishing and Maintaining the Market

A sufficient market is the most significant economic factor relating to industrial minerals. There is usually no automatic and unrestricted demand, and therefore the ability to evaluate the market potential of a mineral is of inestimable importance. A market must be developed before a deposit can be developed with any reasonable certainty of success. Even after an industrial-mineral producer has become established, he must maintain a careful and continuing market study, persuading prospective consumers to evaluate his mineral for specific applications.

The marketing is usually complex. To serve a highly diversified and continually changing market, many operators offer a range of products with different physical or chemical properties. Product research and development and customer service have become increasingly important to successful marketing. They may become rather involved and costly when a new mineral or a new grade of product is being introduced. The selling of products -- established, changing, or new -- must be done skillfully to be effective. The salesman must be fully knowledgeable about the consumer's industry, whether he be a company employee or a sales agent. A producer who has large sales to a particular type of consuming industry often develops his own sales staff--which has better access to his product and market research facilities, can provide more careful service to the consumer, and probably is less costly than an agent. When a multitude of small consumers exists, particularly in one field such as the chemical industry, the sales agent, dealer or broker has an important role to play. Although he is selling many types of products from a large number of producers, he has the market contacts and is therefore a valuable link between producer and consumer. A large producer may use both -- the company salesman for the large-volume business and the agent for the smaller-volume sales. The mineral producer should be wary of expecting his sales staff, who may be experienced in a certain industry, to begin selling effectively to an entirely different industry before becoming thoroughly familiar with that industry's products, requirements, and problems.

A producer has to be able to describe adequately the characteristics of his mineral products, in a language that the consumer can understand and as much as possible in terms that enable his product to be compared with products from other sources. There is much confusion in present terminology. In some cases, the mineral producer must know almost as much about the formulation of the manufactured product as the manufacturer does.

The potential producer of a new and unproven industrial mineral has a special problem. With no previous industrial experience in its use, he must find a market -- sometimes based on the new mineral's ability to substitute for one being used, or sometimes because it has some unusual property. Occasionally, the need for a substance with a certain property can provide a market for a mineral already being used in some other way. Bentonite, which was in use as a binder in moulding sands and stock feed and as a gelling agent in oil-well drilling muds, was available when a binder was needed for making iron-ore pellets.

Consumers in many industries -- particularly makers of paints, ceramics and chemicals -- are very reluctant to change suppliers of industrial-mineral raw materials. It is difficult for an industrial-mineral producer to persuade a company in this type of industry to try his product, to run tests, and to evaluate its use. Because the same mineral from different deposits may differ considerably in physical or chemical properties (sometimes properties vary measurably within the same deposit), a consumer who changes to another supplier may be required to reformulate, which he is usually reluctant to do. Any price advantage resulting from a change, particularly if the mineral constitutes only a small proportion of the consumer's product, may have very little effect on the overall economics of that product.

The use of a mineral is often based on habit or prejudice. A producer may have a suitable mineral product in so far as it meets all specifications, but he may not be able to overcome some bias such as colour, even though the colour may not affect the usefulness of the mineral. Canadian talc, for example, is not used as extensively as it could be in the manufacture of graphitic foundry facings, because it is too white; its colour excessively modifies the black colour of the graphite, although it does not affect the physical property of the facing.

A producer may find that an established market is disappearing because of changing practice. Talc is a common carrier or diluent for dry insecticides, but the trend away from dry and toward liquid insecticides is increasingly curtailing its use in this way.

If possible, a producer should be wary of depending entirely on a market with an unpredictable seasonal or business variation. Fluctuations, for example, in the amount of construction, in oil-well drilling, in the use of such manufactured products as insecticides, or in the availability of inexpensive imported manufactured products such as ceramic ware, will all affect the consumption of the industrial minerals used in those industries. He must try to build a balanced overall market so that he can survive a major change in an individual consuming industry.

Captive Markets

Many an industrial mineral is an important ingredient in an industrial process but plays a rather obscure role. Fluorspar, silica and limestone are used in quantity as fluxes in large and complex metallurgical operations, and in many cases are produced for no other reason than to serve particular operations.

Specifications and Quality Control

Specifications are the guidelines that dictate the type or degree of processing necessary to make a mineral product acceptable for a specific use. In some industries, like construction, specifications are reasonably well defined and accepted, and a mineral producer need only meet them to have a marketable commodity. In many other industries, they are simply a source of great confusion -- essentially a matter of agreement between producer and consumer, with no standardization. The consumer is often guilty of overspecifying. He establishes a set of specifications with one consumer, with a built-in safety margin, and then quotes these specifications to other possible suppliers. Very often the specifications require a finer particle size or a lower impurity content than is really necessary, which is wasteful and costly. For several years, there has been a trend to more exacting specifications, particularly with regard to fine particle size. The paint industry consumes a high-quality mica filler, which used to be wet-ground in oak-lined chaser mills. Because of the platy nature of mica, the minimum practical particle size obtained was minus 200 mesh. The growing demand for finer particle sizes for all raw materials for paints, and many other manufactured products, forced the mica industry to replace this highly specialized processing method, with its well-polished, dust-free product, by fluid-energy grinding in order to guarantee a particle size of minus 325 mesh. The non-standardization of specifications makes the evaluation of a deposit more difficult than it might otherwise be.

The need for specifications led to the need for measuring the quality of products. Quality control is important, but complex. For many industrial minerals, it is a great hodge-podge of non-standardized, non-comparative methods.

The ultimate is approached when a product is tailored to fit a set of exacting specifications, sometimes by the careful blending of grades or by the close control of particle size.

No matter how well located the deposit, how simple the processing method, how advantageous the transportation, and how effective the methods of sales and service, the producer of an industrial mineral is faced with a complex, demanding market that is continually changing. He must be constantly reviewing his market and aware of all pertinent changes.

Transportation

The cost of transportation and distribution — the total cost of moving a product from the production line to the consuming plant — is generally more important to the economics of industrial minerals than to the economics of metals and fuels, and frequently exceeds the cost of the saleable product at the production point.

The Importance of Place Value

Most industrial minerals have low unit values and must be delivered at low cost. Deposits, therefore, are likely to be worthless unless they are located near the market - i.e., they generally must have high place value.

Sand, gravel and crushed stone are prime examples of commodities for which place value is very important and which may be affected adversely by even a small increase in transportation cost. For many other industrial minerals, place value is similarly important, although to lesser degrees.

The importance of place value can be modified by special circumstances. The demand for gypsum (which usually has a relatively high place value) in the densely populated eastern United States and the presence of abundant, high-quality gypsum on tidewater in Nova Scotia and Newfoundland permit the shipping of unprocessed gypsum over unusually long distances to gypsum-products plants on the eastern seaboard of the United States. Similarly, unprocessed barite (which normally has a moderately important place value) can be shipped from Nova Scotia, Ireland and Greece to ports on the Gulf of Mexico for processing.

Sometimes a commodity is needed in a certain market because of a particular physical or chemical characteristic and must be transported regardless of distance. Bentonite, which is worth only about $5 a ton in the unground state in Wyoming, is shipped, at a cost of about $23 a ton, across the continent to iron-ore-pelletizing operations near Sept-Iles, Quebec, and Labrador City, Newfoundland.

Commodities such as sheet mica and graphite have low place value and move long distances to market. These minerals from a particular source have special physical characteristics, and their occurrence in one country and the demand for them in another combine to reduce the importance of transportation costs as an economic factor.

The trend of increasing transportation cost can sometimes encourage the development of a new source of a commodity, to avoid the rising cost of shipping it from a distant source.

Developments in Transportation

The necessity of delivering high-bulk commodities at a low cost has led to many important mechanical developments, and promises even more spectacular innovations in the future. Transportation agencies are providing larger and specially designed equipment, supplemented at either end by better, larger or specialized bulk-handling equipment — to move more tons, more easily, more quickly and more inexpensively. In the coastal waters of British Columbia, a hopper-like barge with its own scraper and hoist for self-unloading and with a capacity of 4500 tons of sand, gravel or stone is now in service. The use of a trainload rate (rather than a rate set on the basis of a carload lot), such as the 4200-ton shipments that are made by the Illinois silica industry to glass plants in the Montreal area, permits some producers to effect savings in freight cost and to ship over longer distances than usual. The unit train — a complete train assigned to carry a specific commodity between two points on a regular schedule — is growing in importance. In July 1967, Canada witnessed the use of its first unit train when thirty-seven 100-ton cars of sulphuric acid were sent from Copper Cliff, Ontario, to a fertilizer plant near Sarnia, Ontario. In addition to a lower shipping cost, the unit train results in increased efficiency, a shorter delivery time and a more reliable supply, but can only be used when a consistently high volume is involved.

The next decade will probably see the extensive use of long-range transportation of solid commodities in a slurry by pipeline. Shell Canada Limited plans to move sulphur from Alberta to the Pacific Coast, a distance of 750 miles, in a 12-inch line, using oil or water as the carrying medium, and expects to reduce its transportation cost of sulphur by one third. Further in the future, the transmission by pipeline of solids in capsules should become important and promises savings in the transportation of many commodities, including sulphur and potash.

Once an operation is automated and the cost of production is reduced as far as possible, the only way to reduce the delivered cost further is by cutting the cost of transportation. Apart from making use of purely mechanical improvements, many industrial-mineral producers are beginning to look at the whole matter of distribution as a unified system. In this way, they may identify more easily a high-cost segment, such as the handling of orders, loading, warehousing, control of inventory, control of traffic, or method of transport. One result has been the increasing use for longer hauls of integrated or intermodal shipping, whereby efficient trans-shipment of a commodity from one mode of transport to another permits a lower rate.

Service through Transportation

Under certain circumstances another modifying factor may affect transportation costs: the ability of an industrial-mineral producer to offer a service through transportation, in terms of delivery, storage, and bulk handling. A customer for rock salt for ice control requires the salt on a seasonal basis, but may not wish to provide warehouse space or bulk-handling equipment or to handle the salt more than once -- and yet he wants delivery when he needs the salt. To compete for this market, the supplier must provide warehousing. He can use terminals strategically located, filled at his convenience and equipped with bulk-handling facilities for offloading and reloading -- which is costly. He can instead use railway cars as warehouses on wheels, and try to predict the time when the salt will be required. A few days' demurrage can provide him with a cheap warehousing cost. He is saved rehandling and is able to re-route cars readily to provide faster delivery and to maintain customer satisfaction. He gambles on the accuracy of his prediction.

When a consumer uses a product continuously, a supplier can schedule deliveries so that cars arrive as needed, without any delay between receiving the order and shipping. The supplier must allow for a possible hold-up at either end, and may attempt to gain some advantage by using captive-service and specially designed cars. International Minerals & Chemical Corporation has begun to use a computerized system for keeping track of up to 6000 railway cars — a system called 'Tels-Car'. 'Roller' cars are kept in motion toward a general market area and can be diverted on short notice to specific customers. They are 'spotted' according to forecasts of demand. This system provides much better delivery than the one requiring receipt of an order before shipping. Similarly, warehouse barges are being used to put products in the consuming area, for quick response to an order.

The producer must also be prepared to ship his products in any amount up to trainloads and boat loads, and in any kind of railway car or boat, and in any kind of packaging, according to consumer need. The salt industry, for example, must be able to supply fine salt in bulk or bags, in 50- to 60-ton cars to textile manufacturers, in 10- to 15-ton units to consumers with limited bulk-handling facilities, in 100-lb bags to customers with small warehouses, such as bakeries, and in 2-lb cartons for household use.

The High-Bulk Factor

A special case in which high place value is almost always essential is the high-bulk commodities, principally sand, gravel and crushed stone. They must be delivered to the consumer at a low price, and must be not only transported as cheaply as possible but also produced at low cost. Of necessity, deposits must be near the market, usually the centres of population.

Mining is generally by a low-cost, open-pit method, although in a few cases high-quality deposits of limestone near markets are being mined by high-tonnage, low-cost underground methods.

Processing methods are mainly simple and inexpensive. If changes in a deposit threaten the producer with the need for a more complex method, he may have to abandon the deposit or be more discriminating in his mining of it. If specifications on products become excessively demanding, a deposit that should continue to be useful but that yields products that do not quite meet the excessive specifications may become valuless as a mineral source.

Research on the beneficiation of inferior raw material will increase as the specifications become more stringent, as the quality decreases, or as the supply nears exhaustion.

The construction industry, particularly, depends on a large supply of low-cost industrial-mineral commodities, mainly of a high-bulk type. In the present economy, high-cost sand, gravel or crushed stone would lead to excessively high construction costs.

Consumer Service

Besides delivering, promptly and in suitable form, products that meet the specifications, industrial-mineral producers are finding it increasingly necessary to offer a service based on technical research. Most producers systematically measure the physical and/or chemical properties of their mineral products; some are finding it necessary to formulate and evaluate such manufactured products as paints, plastics and rubber compounds to demonstrate the usefulness and value of their mineral products. In the highly competitive talc industry, the trend has developed to a few large companies with complex plants, a multitude of products (many carefully tailored to a specific need), careful quality control, and a willingness and ability to provide technical service. The Canadian nepheline syenite industry was able to create and nurture a demand by being willing to provide the research facilities that proved the usefulness of nepheline syenite. It has had to maintain and expand this technical service in order to expand and diversify its market.

Processing Considerations

Specialized Techniques

The preparation of many industrial minerals for market has necessitated or expedited the development and use of specialized techniques and equipment, especially for fine grinding and classification. To avoid the contamination of many products by iron, grinding equipment with non-metallic linings and grinding media have been developed. To provide necessary equipment for producing very fine products, specialized grinding units such as fluid-energy mills and vibration mills have been developed. To provide sufficient control of the particle size of some products, specialized classifiers have been developed. For certain conditions, the development of special beneficiation methods, such as electronic sorting, has been given impetus by the industrial minerals industry.

The sheet-mica products industry is a case of extreme specialization. For many types of equipment used in handling and forming these products, no manufacturer exists. The fabricators of sheet mica products have learned to depend on their own resources and ingenuity to provide highly complex and effective machinery.

Laboratory equipment for testing and evaluating minerals and products is also varied and specialized. Many industries have had to develop or promote equipment for measuring various physical characteristics. Because of the unusual particle shape of asbestos, producers have had to develop methods and equipment for measuring its properties, and even after 100 years are still seeking new and better ways. Bentonite, with its unusual physical and chemical properties, has caused the development of a wide variety of testing methods and equipment -- particularly relating to its use in drilling muds -- for measuring such properties as swelling index and gel strength.

Near-Market Treatment

An industrial mineral frequently contributes only a small amount to the final cost of an industrial product, and may therefore, under favourable conditions, be moved to the consuming area for part or all of its processing. This may occur because suitable deposits are near low-cost transportation routes, as are gypsum and barite deposits in the Atlantic provinces of Canada. It may occur because a particular industrial mineral, along with other raw materials, constitutes only a small part of the final product in which it is consumed, and that all raw materials undergo some processing in the consuming area. It may occur because important deposits of a useful mineral are in a country having no market and little technological experience; e.g., muscovite in India and graphite in Ceylon and the Malagasy Republic are moved to market areas in such countries as the Republic of Germany, the United States and Japan for final processing and consumption. It may occur because the tariffs of the consuming country encourage the import of crude minerals more than processed minerals; it may be economically more sensible to process such raw materials near the market and ship the final product as short a distance as possible to the consumer. Crude barite from Nova Scotia is processed in Louisiana, partly because the United States tariff on ground barite is $6.50 a long ton and on crude barite only $2.55 a long ton.

Substitution

One industrial mineral can be readily replaced by another with better physical or chemical properties, provided the latter is approximately competitive in price. The property of the mineral rather than the specific variety is often the important criterion. One mineral can be substituted for another in many filler or dusting applications, depending on advantages in price or in such properties as colour and particle shape. Nepheline syenite has extensively replaced feldspar in glass manufacture because of better quality (its higher alumina content). Natural abrasives have given way to artificial varieties, which provide more uniform quality. The use of natural graphite has not grown appreciably, because the artificial variety provides much more scope for the development of new products.

Effect of Urban Growth

A growing urban area spurs the construction industry and therefore creates a growing demand for construction raw materials (principally sand, gravel, and crushed stone). Where urban growth is rapid and unplanned with respect to mineral resources, the urban area may spread over untapped deposits and threaten to curtail operations that are supplying these raw materials. Consumption of these minerals results in an expected depletion of resources, but a depletion brought about by restrictive zoning or the excessive withdrawal of land for recreational or other use unnecessarily limits the very raw materials that are essential to urban growth. The farther an urban community has to reach for its construction raw materials, the more it has to pay for its growth.

As well as the economic aspect, the problem also has sociological and political aspects. One can readily sympathize with homeowners, city fathers and the members of planning boards for opposition to nearby surface-mining operations. The mining industry at its worst has been responsible for the loss of large areas of soil cover and has left some hideous scars on the countryside — and in a close environment often contributes noise, dust, heavy traffic, an untidy appearance, and the occasional bit of fly rock.

However, the mineral raw materials are where they are; the deposits are fixed and must be exploited accordingly. Cooperative planning between the minerals producer and the community can result in adequate expansion, sufficient wilderness and recreational areas, and the optimum use of mineral resources. The mineral resources should be protected for future use, the expanding urban area should be protected from any unpleasantness from the mining operations, and the mined-out area should be restored as much as possible to a usable condition. This sort of cooperative planning has been done in some major urban centres in the United States, where the problem has been acute. In the Los Angeles area, steps have been taken to protect major sand and gravel resources from urban intrusion; a part of Virginia adjacent to Washington, D.C., has been surveyed, and its mineral deposits have been preserved; and in the area nearby Seattle, Washington, rather exemplary zoning legislation has been passed that protects the mineral deposits but permits expansion of the city. The problem has become sufficiently important that the United States Bureau of Mines has undertaken studies of selected urban areas and has begun to issue reports to guide in the planning of urban expansion.

The problem has also been recognized in Canada. D.H. Hewitt of the Ontario Department of Mines has studied the Toronto-Hamilton area and begun an inventory of mineral resources. Using statistics for 1960, he wrote that in the Toronto-Hamilton area about 18 1/2 million tons of sand and gravel, worth less than $15 million (about 81 cents a ton at the plant), cost on the average about $1.00 a ton to transport, or a total of more than $18 million. He calculated that if this industry were forced out 10 miles farther the increase in cost of transportation would be about another 35 cents a ton -- quite a significant extra cost to the community.

Cooperation between the producer and the community costs money, and hence is a factor in the economics of mineral production in urban areas. But such cooperation is vital because it may prevent the loss of resources, which in the long run is more costly to both the industry and the community.

Reclamation of Mined Surface

Reclamation of land that has been mined has been an operating cost to only a small segment of the industrial-mineral industry, but is bound to become more significant. Close to urban areas, reclamation is particularly important so that area planning can ensure full use of the land. Beyond urban areas, it is also being carried out in some places to provide agricultural and recreational land.

Reclamation is comparatively easy with a sand and gravel pit; a bulldozer can readily reshape the land. A stone quarry is a more difficult problem, but can be reclaimed for such special uses as recreational areas, outdoor theatres, decorative parklands, and botanical gardens. A very exciting example of reclamation in North America is in the phosphate mining area of Florida, where in 1965 nearly 65 million tons of crude ore were mined in great open cuts. The recovery of the vast areas involved (something that was only begun relatively recently after more than half a century of laying-waste the countryside) has been a major undertaking and an added expense that was necessary to permit use of the land. In 1960, the simultaneous mining and reclamation of phosphate properties in Florida was begun, reducing the reclamation cost by about 40 per cent. About three-quarters of the land that is mined can be reclaimed, the balance being tied up for disposal of waste colloidal clay. Some of the reclaimed land is developed for industrial sites, living areas or recreation, and some is used agriculturally, particularly for growing citrus fruits. Whatever the ultimate use, the land becomes valuable again.

By 1965, 3.2 million acres of the United States (0.14 per cent of the land area) had been affected by surface mining. Sand and gravel operations accounted for 26 per cent (second only to coal with 41 per cent), stone for 8 per cent, phosphate for 6 per cent, and clay for 3 per cent -- a total of 43 per cent for industrial minerals. The growing concern about this problem has led to proposed regulations that would require the reclamation of land disturbed by the mining of such commodities as sand, gravel, stone, and clay.

CONCLUSIONS

Any area enjoying a high rate of growth will generate industrial growth and an increasing demand for raw materials for construction, ceramic products, chemicals, and fertilizers. This means an increasing demand for industrial minerals. People in the area who are responsible for planning and administering this growth must be aware of and understand the various factors that can influence the successful development and recovery of industrial minerals.

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Several papers relevant to the subject of this paper were presented at the Annual General Meeting of The Canadian Institute of Mining and Metallurgy in Vancouver, April 21 to 24, 1968. None has yet been published. The author has a copy of each on file. They are:

G.S. Crawford, "The Port of Vancouver Expects a Huge Increase in Mineral Shipments".

A.D. Fernie, A.R. Harvey and M.J. deLangen, "Major Bulk Loading and Storage Facilities at Port Moody, B.C.".

R.M. Garvey and W.R. Middagh, "How Sherritt Gordon Receives and Handles Phosphate Rock".

John M. Livingstone, "Problems and Developments in Rail Movements from Source to Dock".

Robert E. Loftus, "Planning: The Key to Modern Ocean Transportation".

J.H. Morgan, "The Mineral Industry and Urbanization".

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