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INDUSTRIAL MINERALS—A CRITICAL KEY TO ECONOMIC DEVELOPMENT

HAYDN H. MURRAY
Speaker of the Year
Department of Geology
Indiana University
Bloomington, Indiana 47405

ABSTRACT: Industrial or non-metallic minerals are essential to economic development. The value of industrial mineral production in the United States is over 3 times the value of metallic mineral production. In the developed countries of the world, the value of non-metallic mineral production exceeds the value of metallic mineral production. The development of a modern industrialized society requires quality and reasonably priced industrial minerals in such industries as smelting of copper and iron, manufacturing cement, drilling oil wells, manufacturing ceramic materials, and a host of others. Because transportation costs are high, most industrial minerals are not imported so a country or region must have a good raw material source.

INTRODUCTION

A precise inclusive definition for industrial minerals or non-metallic minerals is difficult because it includes many unrelated minerals that range from low priced materials such as sand and gravel to high priced materials like industrial diamonds. The World Bank report (Noestaller, 1987) defines industrial minerals as comprising all non-metallic non-fuel minerals extracted and processed for industry end uses, some metallic minerals consumed in non-metallurgical applications, and consolidated and unconsolidated rock materials (e.g., sand, gravel, crushed rock, and dimension stone) and manufactured products (e.g., cement and refractories). The Mining Journal (1988) classifies industrial minerals into three economic groups: (1) low-price, large volume commodities such as sand, gravel, and construction materials; (2) medium to high-price, large volume commodities such as chemical and fertilizer minerals (e.g., salt, sulfur, phosphate, and potash); and (3) high price, small volume commodities such as fluorspar, talc, barite, and industrial diamonds.

The low value, high volume construction type materials are mainly used locally, and generally achieve their maximum use in the stage of popultion growth and the economic development of an area. The high value, low volume industrial materials are used in the more industrialized nations and are often traded internationally. A measure of industrial maturity is achieved when the value of industrial or non-metallic minerals and rocks exceeds that of metallic minerals. This point was reached in the United States early in this century and today the

value of the industrial minerals and rocks is about 3 times that of the metallic minerals. Australia just reached this point in the 1980's.

The standard of living in a particular country or area of the world correlates with the availability and production of industrial minerals. The United States, which has a very high standard of living, has an ample supply of most industrial minerals. Without their availability at a reasonable price, the U.S. could not have achieved this high standard of living nor its tremendous industrial growth. The same can be said of Western Europe.

As mentioned before, there is a great diversity of values for industrial minerals. These values range from a few dollars per ton for sand, gravel, and mineral aggregates such as limestone to several million dollars per ton for industrial diamonds. There is also a great diversity in the utilization of industrial minerals. Our building and process industries require quality and reasonably priced industrial minerals. These minerals are an integral and functional part of many, many products such as cement, ceramics, paper, paint, plastics, and a host of other manufactured products. The growth of the non-metallic or industrial minerals correlates to a large extent with the increase of our gross national product (GNP)

INDUSTRIAL UTILIZATION OF NON-METALLIC MINERALS

Industrial minerals are necessary in many industries as mentioned above. Some examples of the minerals that are used and what they contribute to the manufactured products are given as follows. This is by no means complete but does indicate the diversity and functionality of these important industrial minerals.

The building industry could not function without industrial minerals. Cement, which is a necessary component of most of our buildings, is made from industrial minerals that include limestone and shale which is pulverized, mixed together in specified proportions, and heated to form the necessary reaction products that make cement. In buildings and roads the cement is mixed with aggregate which can be sand and gravel or a mineral aggregate such as limestone or trap rock (basalt). If a lightweight concrete is needed then a lightweight aggregate such as bloated shale is used. This bloated shale is formed by rapidly heating crushed shale particles to a temperture in which some volatiles in the shale are released at the same time the surface of the shale particle is melting. The volatiles then form internal voids because they expand when trapped by the viscous glassy outer melted surface. When cooled the shale particles are strong and light in weight and make a good lightweight aggregate for concrete. Other building materials also use industrial minerals. These include wallboard which is made from gypsum, bricks which are made from clays and shales, dimension or building stone which are limestone, marble, granite, and many other rocks, plaster which uses cement and perlite, and tile which uses kaolin, talc, wollastonite, and other minerals.

In making iron and steel, a flux is needed to lower the melting point of the iron ore. This flux is usually high calcium limestone. In making metallic aluminum, a flux normally used is fluorite, another industrial mineral. In smelting copper, an industrial mineral silica sand is used as a flux. Therefore, industrial minerals are necessary in the smelting of metallic ores.

In drilling oil wells. industrial minerals play a very important role. A drilling mud is necessary in order to successfully drill an oil well because the drilling mud is used to carry the tons of rock cuttings up the hole to the surface, it seals the hole by forming an impermeable layer of mud cake on the side of the hole thereby preventing the drilling fluid from escaping into the permeable and porous rock formations, and the mud cools and lubricates the drill bit. The drilling mud is comprised of industrial minerals, the major component of which is usually sodium bentonite. The material when mixed with water forms a material which is fluid when agitated or stirred and is gel-like when allowed to set. This property is called thixotropy. When the mud is pumped down the hole through the drill pipe to the bit it is fluid but is viscous enough to carry the rock cuttings up the hole. If the drilling stops for some reason the drilling mud becomes a gel which prevents the rock cuttings from settling to the bottom and binding the drill bit so that it would twist off when the drilling was started again. Sodium bentonite is naturally thixotropic so is used for drilling oil wells all over the world and is an absolutely essential ingredient. In deep drilling to several thousands of feet the pressure of fluids in the rock formations are very high and if gas or oil is encountered that is under high pressure, the drilling mud could be blown out of the hole and dangerous fires would occur. In order to prevent these blow-outs, a weighting material is used. This finely pulverized heavy material is mixed with the drilling mud to make it heavy enough to contain the bottom hole pressures from blowing out the hole. The most common weighting agent is the industrial mineral barite which is very heavy.

Ceramic materials, which are used extensively in our everyday lives, are made from industrial minerals. Fine china is made using kaolin, silica, and feldspar in proper proportions. Pottery is made from clays and other industrial mineral ingredients. Refractories, for lining high temperature furnaces, use various refractory industrial minerals including kaolin, kyanite, dolomite, silica, and chromite. Glass, which is classed as a ceramic material, is made from high silica sand or quartzite along with a flux such as soda ash. Think of how much glass is used in your homes, cars, and office buildings. This means that it requires the availability of large quantities of high quality silica sand in various parts of the country to sustain our glass manufacturing industry.

Think of how much paper is used every day in your homes and offices. Paper is made from wood pulp but also requires other ingredients which are mainly industrial minerals. Paper requires fillers to give it certain needed properties including whiteness, printability, smoothness, and opacity (hiding power). Industrial mineral fillers are used to give these properties and include kaolin, calcium carbonate, silica flour, talc, and titanium dioxide. For color printing, such as in *National Geographic Magazine*, the paper must be coated and this coating is normally kaolin and/or calcium carbonate along with a minor quantity of titanium dioxide. *National Georgaphic Magazine* is about 35% by weight the industrial mineral kaolin.

In the foundry industry industrial minerals are essential in making the molds into which the molten metal in poured. The engine block in your automobile is made by pouring the hot gray iron into a mold which is made primarily of silica sand and bentonite clay. The mold must be strong enough to hold the molten metal, porous enough to release the gases from the molten metal as it cools, and refractory enough so that it doesn't melt and contaminate the iron. These two

industrial minerals, high silica sand, which is the major component, and bentonite, have the needed properties to make these molds.

Industrial mineral fillers are used in many products including paint, plastics, rubber, and ink. These fillers are not inert fillers but they perform a needed function. Fillers or extenders in paint make the paint film glossy or dull, washable, and smooth, and gives the paint film covering power and body so that it doesn't drip or run. In plastics, mineral fillers make the plastic less brittle so that it does not shatter on impact, makes many plastic materials less vulnerable to infra-red and ultra violet degradation and improves the surface smoothness of the plastic. Some automobile bodies and many boat bodies are made of plastic and contain up to 40% mineral filler, usually calcium carbonate or kaolin. Without the mineral filler the plastic would shatter like glass upon impact. In rubber, industrial mineral fillers are used to improve abrasion resistance, to stiffen the rubber product, to reduce the elasticity, and improve the hardness. In ink, fillers are used to control the viscosity and to improve the covering power. Thus, it can be seen that industrial mineral fillers are a necessary and functional part of many industrial products.

Another area where industrial minerals are used is when a sorptive material is needed. Examples are in machine shops where oil spills commonly occur or in service stations where motor oil is spilled on the floor. An absorptive clay is used to soak up this oil. This type of clay is commonly referred to as fullers earth. These sorptive clays are also used in the agricultural area as carriers for insecticides and pesticides. The largest use by far of these sorptive clays is as cat litter. Over a million tons of this clay are used annually in the United States by cat owners.

There are many, many other industrial uses for many other industrial minerals. The aforementioned examples are only to illustrate how important the industrial minerals have been and are to our industrial development.

LOCATION AND TRANSPORTATION

The location of the low price, high volume industrial minerals with respect to the markets is exceedingly important. In general, the transportation cost of these low priced industrial minerals such as sand and gravel control their marketability because in many cases the transportation cost exceeds the cost of the sand or gravel at the mine. This is the reason that the mines must be located as close to the markets as possible. The urban growth around every major city in the United States has limited the expansion of operating mines and prohibited opening up new mines because of zoning restrictions. Thus, the delivered cost of sand and gravel has increased significantly in most major cities because of the increased cost of transportation. Policy develoment regarding this resource should begin to recognize: (1) the necessary of having a viable sand and gravel industry; and (2) the need to locate and protect these resources needed for the future.

The medium to high price, large volume commodities and the high price, small volume industrial minerals are relatively insensitive to transportation costs although in many cases it is a marketing factor. The high cost of transportation gives considerable incentive to explore and locate resources nearer to markets. In many instances lower quality materials are located and because of the lower

transportation cost additional money can be spent on processing to bring the product into market specifications.

INDIANA'S INDUSTRIAL MINERALS

The industrial minerals produced in Indiana are many and their value is substantial. In 1987, the value of the industrial minerals production in Indiana was $363,900,000. Indiana's industrial minerals actually fall into all three classifications enumerated in the introduction and are as follows:

1. Low value, high volume
   - sand and gravel
   - limestone aggregate and agricultural lime
   - brick clays
   - foundry sand and glass sand
   - marl
   - gypsum
2. Higher value, high volume
   - dimension limestone
   - high calcium limestone
   - filler clay and white firing ceramic clays
   - peat
3. High value, small volume
   - whetstone

Sand and gravel pits are located in all regions of Indiana with the largest concentration of operations in the vicinity of Indianapolis. Limestone aggregate and ag lime operations are also located in all regions of Indiana so that the transportation costs of these low value materials are minimal. Limestone for cement is mined near Greencastle, Mitchell, and Speed.

Brick clays are found in many areas of Indiana although only one plant south of Mooresville is now operating. Marl for agricultural use is mined in northern Indiana near LaPorte. Foundry sand pits are located near Attica and in the Dunes along the south shore of Lake Michigan.

The production of gypsum in Indiana ranks higher than any other state. The location of the two mines producing this important industrial mineral is near Shoals in Martin County, Indiana. The reason for the large production is location. Chicago, St. Louis, Louisville, Cincinnati, and Detroit are large markets for wallboard, which is the major product in which the gypsum is used.

The famous Indiana limestone, which is superior building stone, is quarried in the area between Bloomington and Bedford. This industry is producing at capacity at present and the outlook is rosy for the foreseeable future.

High calcium limestone is produced at five locations, Swayzee, Stinesville, Indianapolis, Orleans, and Leavenworth. The high calcium limestone is used as a flux in the steel industry and as a filler in many process industries. Filler clays and white firing ceramic clays are produced at Huntingburg, Indiana. The filler clay is used in asphalt, rubber, and plastics. Peat is produced in northern Indiana at several locations in Allen, LaPorte, Hamilton, and Madison Counties. The peat is used mainly as a soil conditioner. Natural whetstones are mined and shaped at a small operation near Orleans in Orange County. This is the only high value, low volume product produced in Indiana and it is classed as an abrasive.

SUMMARY

Industrial or non-metallic minerals are relatively unheralded materials but have a much higher value in the United States than the metallic minerals. They are essential ingredients in many process industries including paper, paint, plastics, rubber, ceramic, cement, glass, and many others. Our high standard of living is largely due to our abundant supply of quality industrial minerals. Location and transportation costs are very important for the low cost, high volume industrial minerals and are relatively inconsequential for the higher cost, high volume and high cost, low volume industrial minerals.

Indiana's industrial minerals are important to the state's economy. One of the most important industrial minerals is gypsum and the production in Indiana is larger than that of any other state. Our building construction and agricultural areas are healthy because of the abundance of local sources of sand, gravel, and limestone. The Indiana limestone that is shipped throughout the United States for use as a dimension building stone is an important industry in the Bloomington and Bedford areas. Thus, we can see that industrial minerals are truly a critical key to economic development.

LITERATURE CITED

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