TYPES OF NONMETALLIC ORE-MINERAL RESOURCES

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Keywords: industrial minerals, supply, demand, uses, sources, geology, construction, chemicals, evaporites, aggregates, trends

Contents

Summary

The article first defines what industrial minerals are and then outlines their main properties and uses. It also briefly describes how they occur, whether as primary rocks and minerals, or by weathering and erosion processes from other rocks. It discusses their role in national economies, particularly that of the United Kingdom (UK), and what contribution they make to national wealth, compared with other industries. It looks finally at some of the future trends in industrial minerals. A short bibliography and selection of relevant websites is also included.

1. Introduction

Industrial minerals are an important group of naturally occurring rocks and minerals, which are exploited for their physical and/or chemical properties rather than for their contained metals or energy. They are generally much more common and widespread than the fossil fuels or metalliferous minerals. They tend to have a high place value (i.e., they are mainly used close to their area of production and hence tend to have a low unit value).

Industrial minerals are used for a very wide variety of purposes. They enter into every aspect of our daily life, from food and food processing through chemicals, paints, paper, and plastics production, to road and building construction. They are also usually very widely distributed geographically, though some have a very restricted and particular range of occurrence. Most industrial minerals are used in their country of origin, but there are a significant number that are traded internationally.

2. What are Industrial Minerals?

Industrial minerals are defined as those naturally occurring rocks and minerals of economic value that are extracted, processed, marketed, and used for their physical and/or chemical properties. They are separate from fossil fuels, such as petroleum, coal, or natural gas, and from metalliferous minerals, which are smelted to produce pure metals. Gemstones are also a separate category of materials, as they are valued for their aesthetic beauty, rather than for any particular use.

This definition of industrial minerals encompasses construction minerals, including sand and gravel, and crushed rock aggregates, which in industrialized countries tend to dominate both the volume and value of mineral production. Industrial minerals support a large and diversified extractive industry of worldwide importance, accounting for some 72% of the quantity and 40% of the value of world mineral production, excluding oil and gas.

3. The Geological Development of Industrial Minerals

All industrial minerals are the products of various geological processes from the large to small scale. The formation, weathering, and erosion and redistribution of igneous, sedimentary, and metamorphic rocks all generate various types of industrial minerals.

3.1. Igneous Rocks

Igneous rocks are produced by the generation of liquid magma at depths of 50–700 km in the earth's mantle. The magma then rises, because of its lower density than the surrounding solid rock, until it is either emplaced below the ground surface as an intrusion or erupted onto the land surface as lava and pyroclastic rocks (ashes). Intrusions cool more slowly than lava and are thus generally coarser grained. Igneous rocks characteristically display a texture of interlocking crystals that give the unweathered rocks great strength. They are therefore used as large blocks (armorstone) in coastal defenses. Igneous rocks can also be altered by a variety of surface and subsurface processes to produce a variety of industrial minerals, such as china clay from granites or perlite from rhyolites. The main types of igneous rock are shown in Table 1.

Name	**Grain size**	**Color**	**Density**	**Major minerals**	**Associated industrial minerals**
Granite	Coarse >5 mm	Light (gray to red)	2.64	Feldspars, quartz	Roadstone, building stone,

					quartz, feldspar, china clay, perlite
Gabbro	Coarse >5 mm	Dark (green to black)	3.0	Feldspars, pyroxene	Roadstone, building stone
Dolerite	Medium 1–5 mm	Dark (green to black)	3.0	feldspars, pyroxene	Roadstone, building stone
Rhyolite	Fine <1 mm	Light (gray)	2.5	Feldspar, quartz	Roadstone, building stone
Basalt	Fine <1 mm	Dark (green to black)	3.0	Feldspars, pyroxene	Roadstone, building stone
Pyroclastic rocks (ash, scoria, pumice, etc.)	Very variable	Light to dark	low 0.8–1.5	Very variable	Building stone

Table 1. Igneous rocks

3.2. Sedimentary Rocks

Sedimentary rocks are formed by processes acting at or near the surface of the earth. Typically, they are formed by the sedimentation of particles eroded from pre-existing rocks and/or minerals on the sea or lake floor, and consolidated into solid rock by the pressure of overlying rocks from later deposition. Sedimentary rocks typically have a bedded structure caused by successive layers of sediment settling to the sea or lake bed. They can also be formed from the skeletons or shells of animals accumulating on the sea floor. Coal is generally formed from the anaerobic accumulation of plant material in nonmarine swamps, followed by burial and compression under the weight of succeeding deposits. Evaporites are formed by the continued evaporation of sea or lake water until the contained salts precipitate onto the sea or lake bed. The main types of sedimentary rocks are shown in Table 2.

Name	**Grain size**	**Color**	**Density (wet)**	**Major minerals**	**Associated industrial minerals**
Sandstone	Variable from coarse > 5 mm to fine < 1 mm	Light (gray, red and green)	2.35	Quartz, feldspars	Roadstone, building stone
Limestone	Generally fine <1 mm, can contain	Light (gray)	2.55	Calcite, dolomite	Roadstone, building stone,

	fossil shells				calcite, cement and lime
Shale	Fine 1–5 mm	Dark (gray to black)	2.4	Clay minerals	Construction -fill material
Clay	Very fine	Dark (gray to black)	2.4	Clay minerals	Clay minerals
Evaporites	Fine < 1 mm	Light (white to gray)	2.2 (halite)	Halite, sylvinite, gypsum	Halite, potash, gypsum

Table 2. Sedimentary rocks

3.3. Metamorphic Rocks

Metamorphic rocks are formed from pre-existing igneous and sedimentary rocks by the application of heat and/or pressure. This may occur when igneous intrusions heat the surrounding rocks above the ambient temperature, or when rocks are buried deep in the crust by earth movements, which increase the lithostatic pressure. As the temperature and/or pressure increases, some minerals undergo physical and/or chemical changes, or metamorphism. New minerals may form or recrystallization of the existing minerals may occur. The effects of applying similar pressures to different rock types can be quite different. Thus, fine-grained limestones can change into crystalline marble with an increase in grain size of the calcite crystals, while the clay minerals in mudstones or shales orientate themselves at right angles to the direction of maximum pressure to form slates with a cleavage fabric along which the rock will easily split. As metamorphism becomes more extreme new minerals may form, such as micas and/or garnets, and the rock becomes a schist, still with a pronounced cleavage fabric. Sometimes gemstones—mainly varieties of aluminum silicate or corundum containing variable quantities of impurities to form sapphires, rubies, or topaz—can be formed. At very high pressures and temperatures the rock mass can begin to melt and minerals segregate to form very hard and tough gneiss with a typical banded structure of light- and dark-colored bands. Metamorphic rocks tend to have dominant fabrics, called cleavage and schistosity. These fabrics can be an important factor in the use to which metamorphic rocks are put. For example, metamorphosed mudstones can be split into very thin sheets as slates for roofing. The weathering and erosion of metamorphic rocks can liberate minerals such as garnets, corundum, or gemstones, which may be economically concentrated in river gravels or beach sands. The main types of metamorphic rocks are shown in Table 3.

Name	**Main parent rocks**	**Color**	**Density**	**Major minerals**	**Associated industrial minerals**
Slate	Mudstone/fine-grained volcanic ash	Variable	2.8	Clay minerals	Slate, andalusite
Schist	Mudstone	Dark (green to black)	2.6	Quartz, mica, feldspar	Abrasives (garnet, corundum, etc.), gemstones

Gneiss	Any	Characteristically banded	2.8	Quartz, feldspar	Quartz, gemstones
Amphibolite	Basalt	Dark (green to black)	3.0	Amphibole, feldspar	Roadstone
Quartzite	Sandstone	Light (gray)	2.6	Quartz	Roadstone
Marble	Limestone or dolomite	Light (gray)	2.75	Calcite or dolomite	Marble

Table 3. Metamorphic rocks

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Websites

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British stone <http://www.british-stone.com/index.htm>. [This has links to many British stone producers.]

General stone information <http://www.graniteimpex.com/index.html>. [This has a wealth of international information.]

Gypsum information <http://www.eurogypsum.org>. [This is the website of the Association of European Gypsum Producers with much information on gypsum and plasterboard]

Industrial Minerals publication <http://www.mineralnet.co.uk>. [This has many links to other industrial mineral websites.]

Marble information <http://www.marbleintheworld.com>.[This has examples of marble, granite and other stone producers' products worldwide and links to many other stone sites]

Mineral statistics <http://www.mineralsuk.com>. [This has British and worldwide production and other information.]

Potash information <http://www.clevelandpotash.ltd.uk>. [This has links to other potash and related sites.]

Biographical Sketch

Tim Colman is an economic geologist with the British Geological Survey, Keyworth, Nottingham, UK. He obtained his B.Sc. in Geology at Durham University in 1969 and then spent three years as an exploration geologist in Australia. He obtained his M.Sc. in Mining Geology and Mineral Exploration at Leicester University in 1973, and after further mineral exploration in Ireland and some years school teaching, joined the British Geological Survey in 1980. He has since been involved in mineral exploration and other minerals-related interests. He is currently a Principal Scientific Officer in the Economic Minerals and Geochemical Baseline Programme Onshore Minerals and Energy Resources Programme.