Mineral Resources of the Northeastern US:
a brief review

A mineral is a naturally occurring solid with a definite chemical composition and crystalline structure that is formed through inorganic processes. Minerals are literally the foundations of our everyday world. Not only do minerals make up the rocks we see around us in the Northeast, they are used in nearly every aspect of our lives. The wide variety of minerals found in the rocks of the Northeast, are used in industry, construction, machinery, technology, food, makeup, jewelry, and even the paper on which these words are printed.

Minerals provide the building blocks for rocks. For example, granite, an igneous rock, is typically made up of crystals of the minerals feldspar, quartz, mica and amphibole. Sandstone may be made of cemented grains of feldspar, quartz and mica. The minerals and the connections among the crystals define the color and resistance to weathering of a rock.

Elements:
the building blocks of minerals

Elements are the building blocks of minerals. The mineral quartz, for example, is made of the elements silicon and oxygen. Most minerals present in nature are not composed of a single element, though there are exceptions such as gold (Au). Eight elements make up (by weight) 99% of the Earth's crust, with oxygen being by far the most abundant (46.4%). The remaining elements in the Earth's crust occur in very small amounts, some in concentrations of only a fraction of one percent (Figure 6.1). Since silicon (Si) and oxygen (O) are by far the most abundant elements in the crust by mass, it makes sense that quartz (SiO2, silicon dioxide or silica) is one of the most common minerals in the Earth's crust and is found all over the Northeast.

Luster refers to the appearance of the mineral surface in reflected light. Metallic minerals have a luster like an aluminum pan or a dull metal like a rusty nail. Metallic minerals are vital to the machinery and technology of modern civilization. Geologists seek out ores that contain significantly more metal than is normal in the crust. Many metallic minerals occur in extremely small amounts in the crust. It is almost always necessary to process ore minerals in order to get the useful element. A mineral is called an ore when one or more of its elements can be profitably removed. For example, ***chalcopyrite***, which contains copper, iron and sulfur, is referred to as an ore when the copper can be profitably extracted from the iron and sulfur.

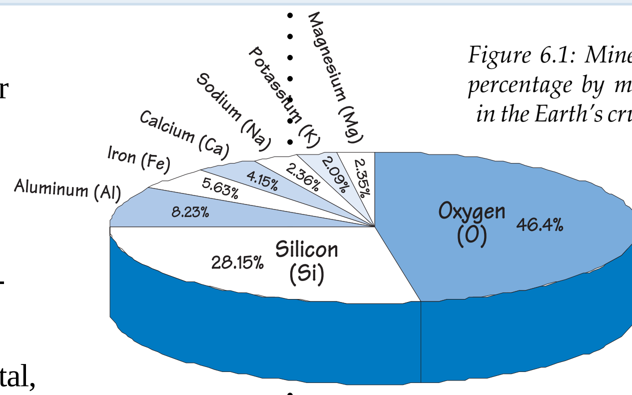
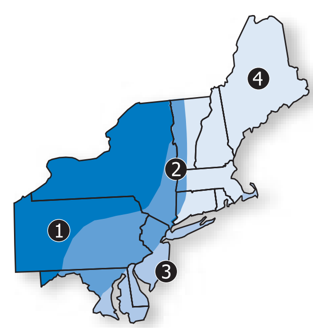


Figure 6.1: Mineral percentage by mass in the Earth's crust.

chalcopyrite: *$CuFeS_2$*

Non-metallic minerals do not have the flash of a metal, though they may have the brilliance of a diamond or the silky appearance of gypsum. Generally much lighter in color than metallic minerals, non-metallic minerals can transmit light, at least through pieces or edges.

What distinguishes a regular mineral from a gem? Beauty, durability and rarity of the mineral qualify it as a gemstone. Beauty refers to the luster, color, transparency and brilliance of the mineral, though to some degree it is dependent on the skillfulness of the cut. Most gems, including tourmaline, topaz and corundum, are durable because they are hard (scratch-resistant). On the Mohs Scale



Mohs Scale of Hardness

In 1824, the Austrian mineralogist, F. Mohs, selected ten minerals to which all other minerals could be compared to determine relative hardness. The scale became known as Mohs scale of hardness, and is very useful as a means for identifying minerals or quickly determining hardness. A piece of glass has a hardness of approximately 5 on the scale; your fingernail is just over 2; and a pocketknife blade is just over 5.

1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Feldspar
7	Quartz
8	Topaz
9	Corundum
10	Diamond

calcite: *$CaCO_3$*

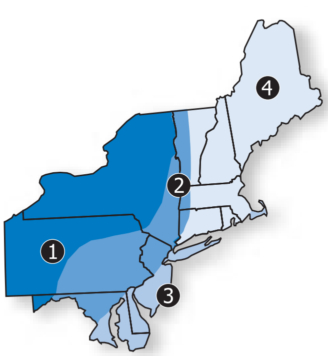
of Hardness, the majority of gemstones are greater than 7.

Hardness is important because it helps us understand why some rocks are more or less resistant to weathering and erosion. Quartz (7 on Mohs scale) is a relatively hard mineral, but ***calcite*** (3 on Mohs scale) is significantly softer. Therefore, it should be no surprise that a quartz sandstone is significantly more resistant to erosion and weathering than a limestone, the primary constituent of which is the mineral calcite. Quartz is a very common mineral in the Earth's crust and very resistant due to its hardness and relative insolubility. Thus, quartz grains are the dominant mineral in nearly all sands.

A gem's value is also dependent on the rarity of the mineral. With limited supply (commercially or in nature), the value of a gem increases significantly, such as with rubies or diamonds. Quartz may have a brilliant luster and be quite durable, but it is hardly rare. Therefore, quartz has significantly less value as a gemstone, though some microcrystalline and colored varieties of quartz are of moderate value.

Geologists looking for particular minerals do not make haphazard guesses as to the location of ore bodies. The occurrence of minerals in the Earth's crust is due to the geologic processes that formed certain rock types in a given area. An understanding of the environments in which minerals form, the minerals that make up different rocks, and the geologic history of an area, helps the geologist to ascertain with a higher probability where minerals of interest are concentrated. Metallic minerals are often associated with igneous and metamorphic rocks, which typically occur in either very ancient rocks (Precambrian) or in areas of severe deformation of the crust (such as where continents have collided) *(Figure 6.2, 6.3)*.

Non-metallic minerals are found associated with sedimentary, igneous and metamorphic rocks of all ages, and in both deformed and undeformed crust *(Figure 6.2, 6.4)*. The apparent concentration of non-metallic minerals along the east coast



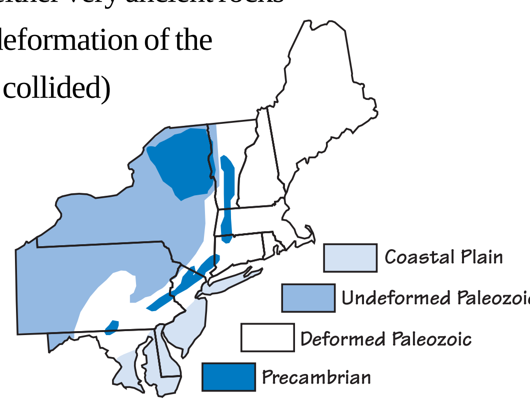


Figure 6.2: Generalized geology of the Northeast.
Figure adapted from USGS 1998 Mineral Resource Evaluation of the Northeastern U.S.

of the United States reflects the high demand for non-metallic minerals in a densely populated region that has led to intense mining of the immediate area.

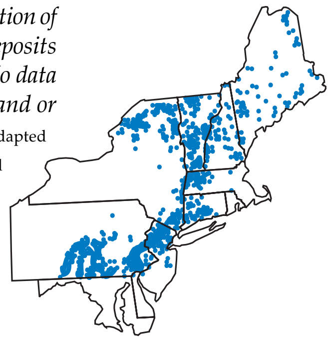


Figure 6.3: Distribution of metallic mineral deposits of the Northeast. No data available for Maryland or Delaware. Figures adapted from USGS 1998 Mineral Resource Evaluation of the Northeastern U.S.

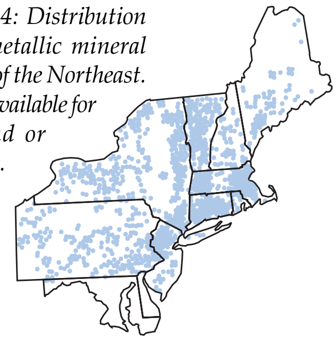


Figure 6.4: Distribution of non-metallic mineral deposits of the Northeast. No data available for Maryland or Delaware.

Mineral deposits may be formed in one of several ways: evaporation of water; crystallization of magma or lava; or the dissolution and later precipitation of minerals by hot water moving through cracks and openings in the rock well below the surface. A mineral is not necessarily restricted, however, to one method of concentration or environment of formation. For example, gypsum may form as a precipitate from evaporating water, but is also associated with volcanic regions where limestone and sulfur gases from the volcano have interacted.

Common rock-forming minerals

There are over 3,500 different minerals identified in the world, and a wide variety occur in the Northeast. However, the number of common rock-forming minerals is much smaller. The most common minerals that form igneous, metamorphic and sedimentary rocks (and the ones that you will most commonly see) include quartz, feldspar, micas, pyroxenes and amphiboles. Though quartz occurs in several colors, it is most commonly white, gray or clear. Feldspar may be a variety of colors, including pink, white, and black or gray. Mica, a thinly sheeted, flaky mineral, is most commonly either light in color (muscovite) or black (biotite). Pyroxene and amphibole are dark green to black, generally needle-like crystals.

In the discussions of each region to follow, the focus is on: currently mined and other significant minerals; where the minerals are most common (though they may occur in other places as well); and how the minerals formed in each particular area relate to the surrounding rocks and geologic history.

What are hydrothermal solutions?

Hot water moving through rocks, also known as hydrothermal solutions, is always enriched in salts (such as sodium chloride NaCl, potassium chloride KCl, and calcium chloride $CaCl_2$) and thus is called a 'brine'. The brine is as salty or even saltier than seawater. Salty water, surprisingly, may contain minute amounts of dissolved minerals such as gold, lead, copper and zinc. The presence of salt in the water suppresses the precipitation of the metallic minerals from the brine because the chlorides in the salt preferentially bond with metals. Additionally, because the brine is hot, minerals are more easily dissolved, just as hot tea dissolves sugar more easily than cold tea. These hot water brines, or hydrothermal solutions, can have varying origins. As magma cools, hydrothermal solutions form because water is often released into the surrounding rock. The water is hot because the nearby magma is still hot (though cooling). Rainwater becomes a hydrothermal solution by picking up salt as it filters through rocks. And seawater (already enriched in salt) is often a hydrothermal solution in the vicinity of volcanic activity on the ocean floor where tectonic plates are pulling apart. Rapid cooling of the hydrothermal solution over short distances allows concentrations of minerals to be deposited. Water moving quickly through fractures and openings in the rock, experiencing changes in pressure or composition, and dilution with groundwater can rapidly cool a hydrothermal solution. Figure by J. Houghton.