Mineral Resources of the Exotic Terrane

Region 4

The formation of the igneous and metamorphic rocks that dominate the Exotic Terrane region provided the perfect conditions for spectacular concentrations of metallic and non-metallic minerals. The first chartered mining company in the US started in the Exotic Terrane region in 1709 at the Simsbury Copper Mine, Connecticut (now East Gransby, CT). Other very early mines were located in the Blue Hills along coastal Maine.

Metallic Minerals

With the collision of the Taconic volcanic islands in the Ordovician, Baltica and Avalonia in the Devonian, and the final collision with Africa during the Permian, the various slices of the Exotic Terrane region have undergone significant periods of compression, deformation, metamorphism and intrusion by magmas. These dynamic geologic conditions gave rise to the formation of many metallic minerals (often associated with igneous and metamorphic rocks). Granite pegmatites, common in this area, often include uranium, gold, antimony, graphite, and iron. ***Gold***, lead, silver and copper are associated with the metamorphic rocks in the region and commonly found in association with one another.

Exceptionally fine quality crystals of ***pyrite***, 'fools gold,' are found in Chester, Vermont. A very common and widespread mineral, pyrite forms in igneous, metamorphic and sedimentary environments as well as through the chemical alteration of other minerals. Other metallic minerals and ores found in the Exotic Terrane region include molybdenum, cobalt, nickel, tin, and tungsten.

The largest manganese deposit on the North American continent is found in Maine in Silurian rocks of Aroostook County. The mildly metamorphosed Silurian rocks were once sediments at the bottom of the Iapetus Ocean. Concentrations of manganese commonly form on ocean bottoms today.

Non-Metallic Minerals

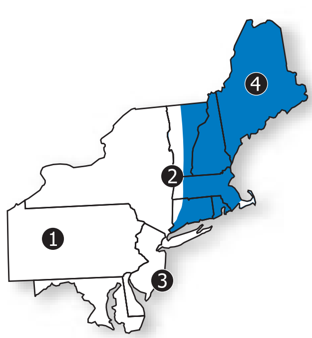
The primary non-metallic minerals of the region are metamorphic and pegmatite minerals, which are so common in the Exotic Terrane area because of the foundation of igneous and metamorphic rock.

Gold

Gold (Au) has been found throughout the Exotic Terrane region as well as the Appalachian/Piedmont. However, having an average abundance in the crust of only 0.004 parts per million, gold can be profitably mined only where hydrothermal solutions have concentrated it. Gold is not found in high concentrations in the Northeast. Most often occurring in its native state (not combined with other elements), gold has been found in stream sediments in very small amounts.

pyrite: *FeS*

Manganese *(Mn) is used in the production of steel.*



in Metamorphic Rocks

The process of metamorphism ranges from low grade (with only mild increases in pressure and temperature) to high grade (with severe increases in pressure and temperature). Mildly deformed rocks may be subjected to very low grades of metamorphism and outwardly exhibit little change in appearance. Severely deformed rocks, on the other hand, have usually been subjected to very high grades of metamorphism and appear distinctly different. The higher the degree of metamorphism, the greater the change is to the original rock. The changes include, to varying degrees, the alignment of minerals within the rock, recrystallization of minerals, and, in many cases, the crystallization of new minerals.

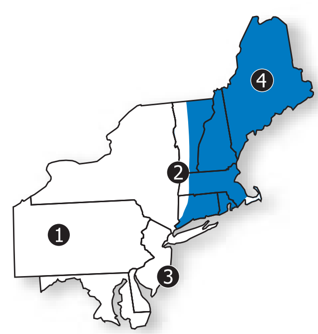
Geologists have determined that specific minerals will form at specific temperature and pressure conditions when a given type of rock is metamorphosed. Low-grade metamorphism of clay-rich rocks such as shale, produce the mineral chlorite. Higher-grade increased metamorphism produces the minerals kyanite and sillimanite. The minerals associated with certain grades of metamorphism are known as index minerals, indicative of the combination of the temperature and pressure conditions a rock has undergone *(Figure 6.13)*.

METAMORPHIC GRADE	Clay-rich rocks	Limestone	Mafic igneous rocks
low ↓ high	chlorite biotite staurolite kyanite sillimanite	chlorite garnet hornblende augite	chlorite garnet hornblende

resulting metamorphic minerals

Figure 6.13: Minerals formed through varying degrees of metamorphism in different types of rocks.

Thus, by examining the minerals found in the Exotic Terrane region, it is clear that the rocks have been metamorphosed to varying degrees. Chlorite is found in northern Maine, indicating that the rocks were only mildly deformed because they were not the center of the collision between continents and have fewer igneous intrusions. Eastern New Hampshire and southern Maine, however, clearly show evidence of high-grade metamorphism by the presence of minerals such as sillimanite and kyanite.



Considering the plate tectonic history of the Exotic Terrane region, the

The Taconic, Acadian and Alleghanian mountain-building events repeatedly compressed and deformed the rocks of the Northeast.

The grade of metamorphism generally decreases to the west, with variation due in part to contact metamorphism by intrusions of magma.

see Minerals, p. 134 for more on **garnet.**

presence of ***high-grade*** metamorphism in the rocks is no surprise. The rocks with high-grade metamorphic minerals indicate the area of greatest stress during the episodes of mountain building throughout the Paleozoic, as well as areas that have been intruded by magma.

Garnet, a metamorphic mineral indicative of moderate metamorphism, is found throughout the Exotic Terrane region. Connecticut has spectacular garnets in the metamorphic rock, mica schist. Garnet is used as a gemstone and an abrasive in sandpaper and polishing. The substitution of different elements into the crystal structure produces several common types of garnets, all of which have the same basic chemical composition: uvarovite, pyrope, andradite, almandite, grossularite and spesartite. Almandite is particularly common in Connecticut.

Gemstones and Other Non-Metallic Minerals

The plate tectonic history of the Exotic Terrane region provided the right conditions to produce slow-cooling magmas far below the surface. Volatiles escaping from those deep magma chambers, enriched in water and rare elements, led to the creation of outstanding pegmatites: lithium pegmatites in Massachusetts; phosphate pegmatites in New Hampshire; and the famous gem-quality tourmalines and beryl of Maine. The first Maine tourmaline, and the start of gemstone production in the United States, was mined at Mt. Mica, where crystals have been found as large as 39.4 cm long, 17.8 cm wide and weighing 14.3 kg. Many minerals in a pegmatite are common and not gem quality, such as quartz, mica, and feldspar. However, gemstones frequently are found in association with ***pegmatites***. Other gemstones found in the Exotic Terrane region include garnet, zircon, topaz, corundum, feldspar, and quartz varieties including jasper, rock crystal, amethyst, and smoky, rose and clear quartz.

see Rocks, p.52 for more on **pegmatites.**

Pegmatites *often contain rarer minerals such as lithium, beryllium, uranium, lepidolite, spodumene, apatite, and fluorite, in addition to the more common quartz, feldspar, and mica.*