Non-Mineral Resources of the Northeastern US:

Non-mineral resources include: the sedimentary, igneous and metamorphic rock that we quarry for buildings, monuments, construction and decoration; deposits from the glaciers that covered much of the Northeast over the last two million years, such as clay, peat, sand and gravel; and the soil, which provides the nutrients and minerals for crops, forests and grasslands. Non-mineral resources also encompass the fossil fuels: coal, oil and gas. Just as minerals are vital to the economy and functioning of modern civilization, so too are the non-mineral resources found in the Northeast. According to the Mineral Information Institute, every American born will need in a lifetime, on average, 3.75 million pounds (1.7 million kilograms) of natural resources, including minerals *(Figure 7.1)*. The maps in this chapter depict the principal non-mineral resources currently being mined in each region of the Northeast.

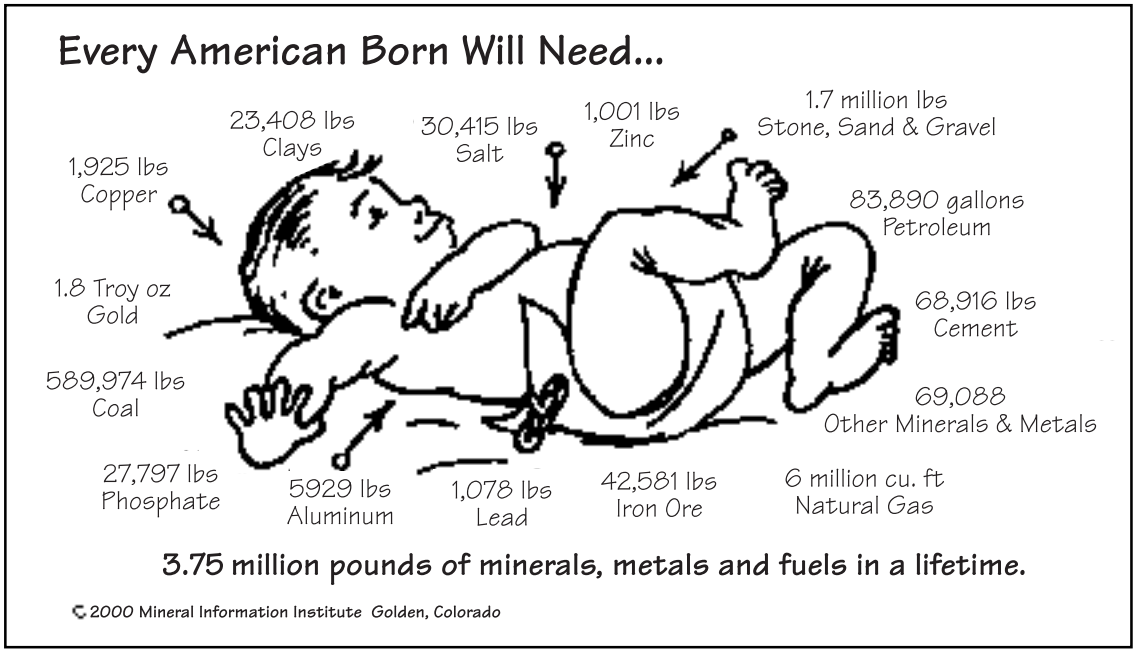
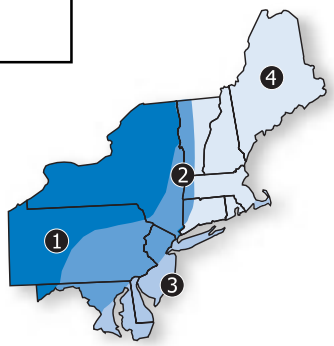


Figure 7.1: Mineral Information Institute mineral and non-mineral resources statistics.



Non-Mineral Resources of the Inland Basin

Region 1

The Inland Basin has an enormous wealth of non-mineral resources. The thick sequences of sedimentary rocks that dominate the basin are important for providing sandstone, carbonate rocks, shale and cement that are used in buildings and construction. Metamorphic gneiss of the Adirondacks, commercially called granite, is mined in Essex County, NY. The Inland Basin is also rich in fossil fuel resources, including coal, oil and natural gas.

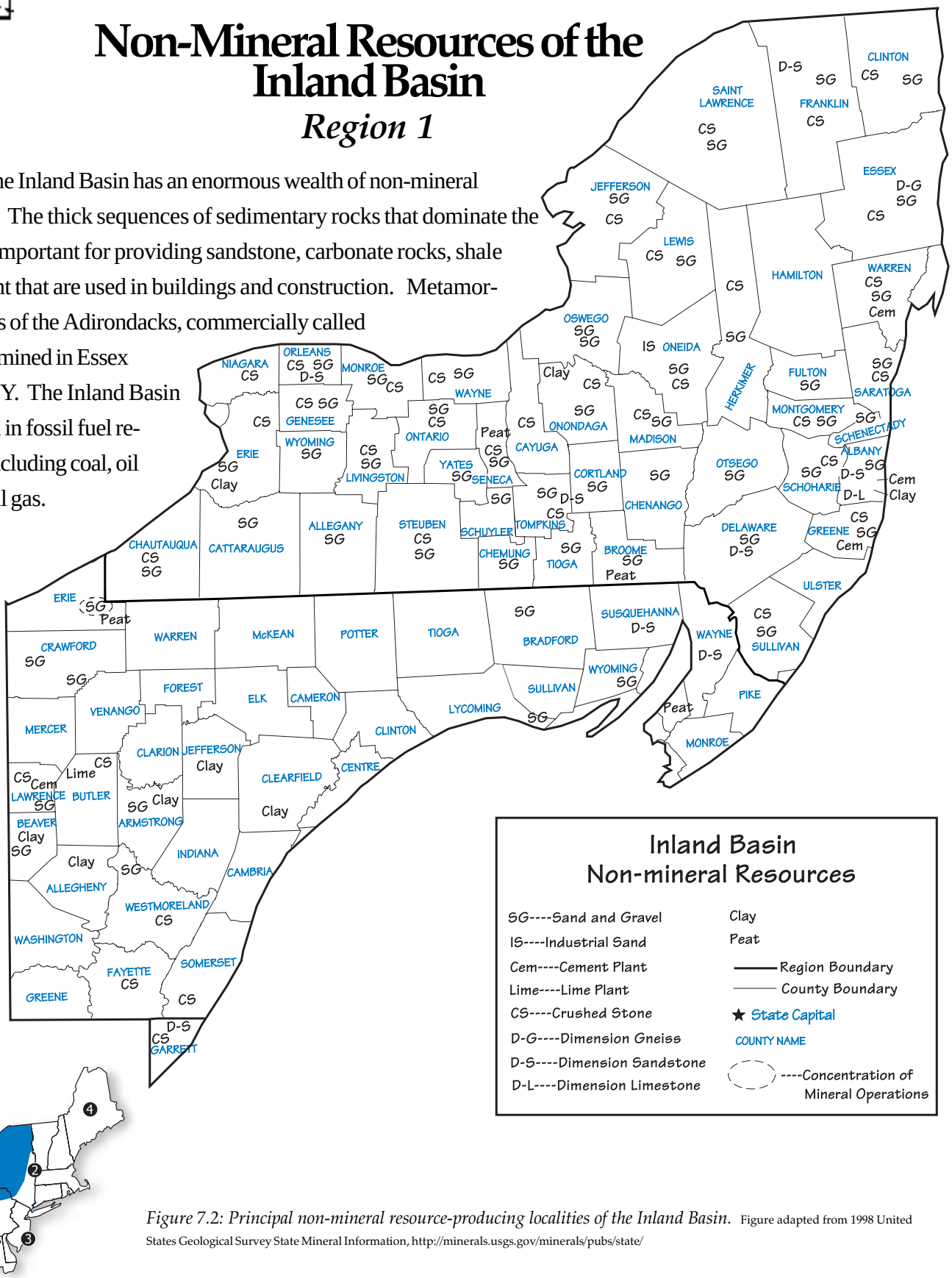


Figure 7.2: Principal non-mineral resource-producing localities of the Inland Basin. Figure adapted from 1998 United States Geological Survey State Mineral Information, http://minerals.usgs.gov/minerals/pubs/state/

Sedimentary Rock

The sandstone, siltstone and shale of the Inland Basin were formed by the Queenston and Catskill ***Deltas*** in the Ordovician and Devonian, and were composed of sediments eroding into the inland ocean from the successive Taconic and Acadian Mountains. As relative sea level rose and fell, different sediments were deposited in a given area. The shale represents deeper, quieter water; siltstone and sandstone represent shallower water and a more energetic environment. During periods when less sediment was being carried into the inland ocean, limestone and dolostone (carbonate rocks) formed.

see Geologic History, p.7 and 12, for more on **deltas.**

Sandstone is quarried throughout the Inland Basin region as a ***dimension stone***. The most famous dimension sandstone of the region is bluestone, found in northeastern Pennsylvania and the Catskills of New York. These well-laminated sandstones with distinct horizontal bedding are called 'bluestone' because the mineral feldspar lends a bluish-tint to the rock, though a variety of colored sandstones are now commercially sold as bluestone. The bluestone industry dates back to the 1800's, and quickly grew until bluestone became commonly used throughout the Northeast as flagstones, sidewalks, curbs, building stones and patios. The industry has gradually declined since its peak in the late 1800's, and now cement has taken the lead economically.

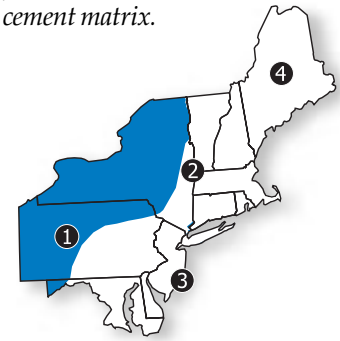
Dimension stone *is the commercial term applied to quarried blocks of rock cut to specific dimensions and used for buildings, monuments, facing and curbing.*

Industrial sand, though once taken from surficial deposits left by the glaciers, is now produced from crushed sandstone or quartzite. Industrial sand, primarily composed of quartz (silica), is distinguished from glacial sand and gravel deposits, which are less uniform in composition. Industrial sand is important for sandblasting, filter sand, making bricks for furnaces and ovens, mixing with clay to make metal castings, and manufacturing glass. Limestone and dolostone, used in agriculture, the chemical industry, and construction, are also important components of ***cement*** and ***concrete***. In some areas, limestone is also quarried as a dimension stone for buildings and facings.

There are two varieties of **cement:** *natural and Portland cement. Both types incorporate limestone. Natural cement uses limestone with a particular amount of clay that hardens into a cement. Portland cement is made through a heated combination of limestone with other rocks and minerals.*

Concrete *consists of gravel, pebbles and broken rock with a cement matrix.*

Used in the steel and glass industries and for pottery and bricks, clay has also long been an important natural resource of the Inland Basin region. The extremely fine-grained, smooth nature of pure clay, which makes it ideal for these purposes, is a result of its environment of deposition. Clay-sized particles do not settle unless the water is a very low energy environment. Thus, the main sources of clay are glacial lake bottoms and the marine shales of the westward reaches of the Paleozoic inland ocean.



Non-Mineral Resources

Granite *is an igneous rock and gneiss is a metamorphic rock, though they are often lumped together under the name 'granite' for commercial uses.*

see Geologic History, p. 4, 6 and 10

*Coal, oil and gas are all are made of the remains of plants and animals, hence the term '**fossil fuels**.'*

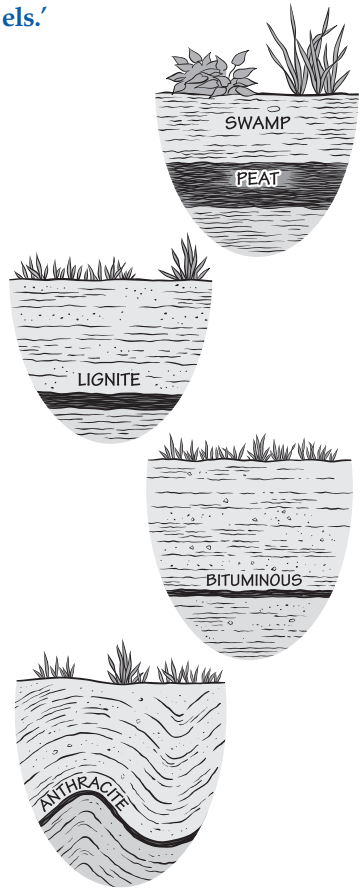
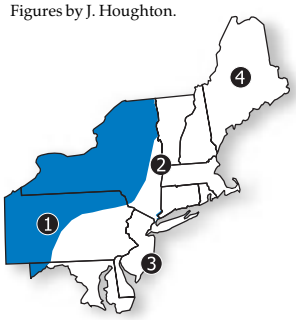


Figure 7.3: The formation of coal.
Figures by J. Houghton.



Metamorphic Rocks

Though sold commercially as '***granite,***' Precambrian Grenville gneiss of the Adirondacks is quarried in Essex County, New York for use as dimension stone. The gneiss formed from the metamorphism of Grenville sedimentary rocks, deposited in the Iapetus Ocean.

Fossil Fuels

Fossil fuels include coal, oil and natural gas; the Inland Basin produces all three. These fossil fuels are clearly important to our economy and standard of living, providing the fuel we need for heating, cooling, cooking, driving and operating in everyday life.

The abundance of plant material in swamps, bogs and marshy areas makes these environments ideal for the formation of coal. As sediment is flushed into the swamp by water, plant material is buried. Bacterial decay of large quantities of plant material uses up available oxygen, causing aerobic decay rates to drop. In non-swampy conditions, running water replenishes oxygen to the bacterial community, and plant material rots away. As organic material gets buried more and more deeply, pressure on it builds from overlying sediments, squeezing and compressing the peat. Coal becomes successively more enriched in carbon as water and other components are squeezed out: peat becomes lignite, bituminous and eventually anthracite coal, which contains up to 95% carbon. Found in deformed rocks, anthracite is the cleanest burning of the four types of coal, because it has the highest amount of pure carbon. By the time a peat bed has been turned into a layer of anthracite, the layer is one-tenth its original thickness *(Figure 7.3)*.

In the Inland Basin, only Pennsylvania and Maryland have layers of coal. However, the Inland Basin coal is the northernmost extent of a long expanse of coal that stretches down the Allegheny Plateau the length of the Appalachians. The existence of coal in the region is a result of the inland ocean formed from the Acadian mountain-building event in the Devonian period. The inland sea became increasingly shallow as sediment from the Acadian Mountains filled in the ocean basin and worldwide sea level gradually dropped. Widespread coastal wetlands, river floodplains, and swampy areas were perfect for the accumulation of dead plant material, which was later compressed enough to become bituminous

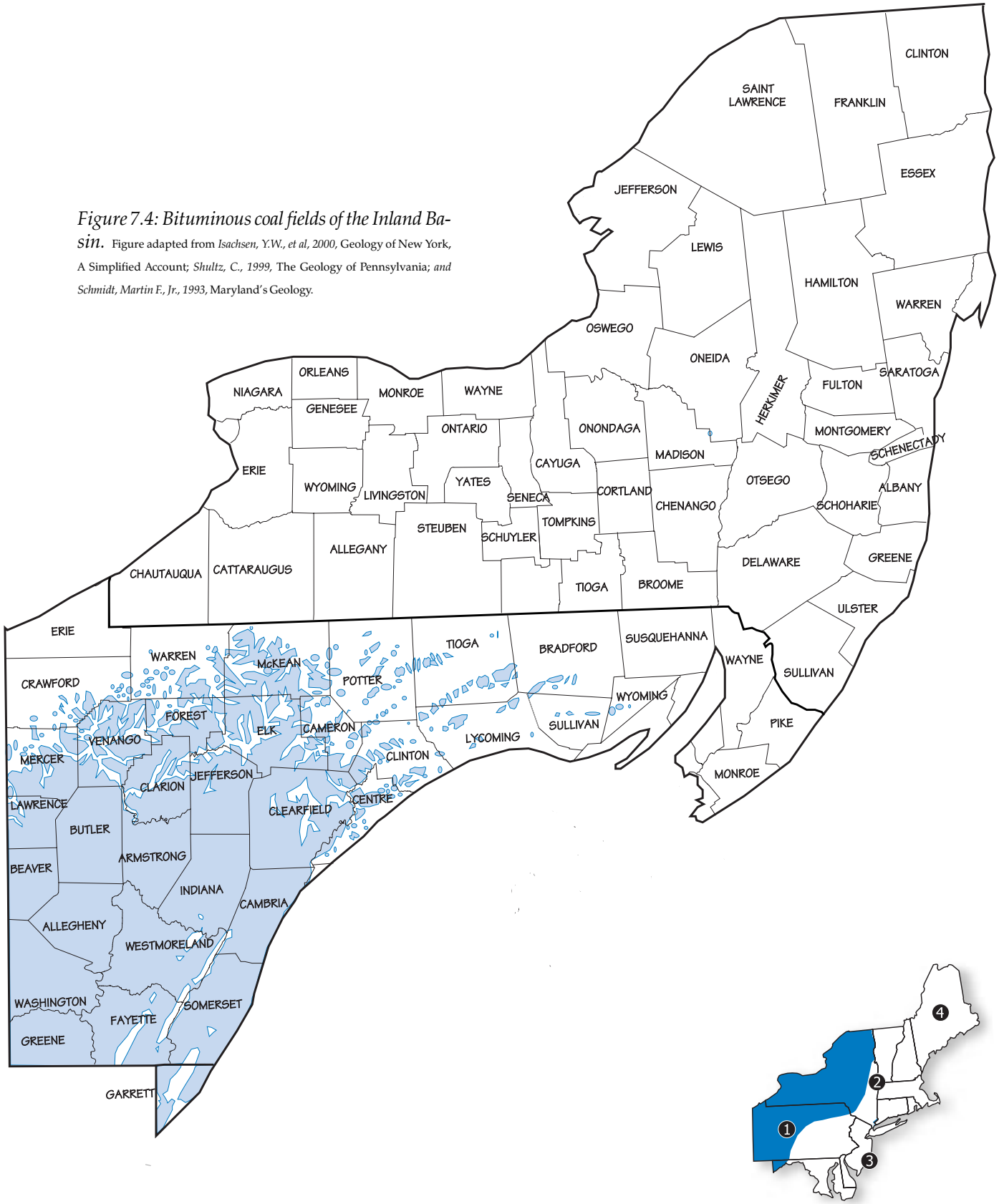


Figure 7.4: Bituminous coal fields of the Inland Basin. Figure adapted from *Isachsen, Y.W., et al, 2000,* Geology of New York, A Simplified Account; *Shultz, C., 1999,* The Geology of Pennsylvania; *and Schmidt, Martin E., Jr., 1993,* Maryland's Geology.

see Fossils, p.5

coal. Plants had only just arrived on the scene during the Silurian period. Diversification and evolution of plants was rapid, leading to a proliferation of swamp loving land plants during the Pennsylvanian, when the coals from the Inland Basin formed. During the Pennsylvanian, a tropical climate prevailed because the Northeast was at the equator. Globally, Pennsylvanian-age rocks produce more than 80% of the world's coal.

Coal is not usually found as a single bed. More often one sees repeated cycles of coal layers and sedimentary rock layers. These cycles are called 'cyclothems,' and are evident in the coal-rich area of the Inland Basin region.

Coal cyclically alternates with other sedimentary rocks during the Pennsylvanian. This cyclicity in sedimentation reflects cyclicity in sea level, repeatedly creating and submerging coastal environments appropriate for coal formation. Because the Inland Basin was not severely deformed and compressed, the coals of Maryland and Pennsylvania are bituminous, unlike the ***anthracite*** coal found further east in the intensely folded Appalachian/Piedmont region *(Figure 7.4)*. Strip-mining is the primary means employed in the extraction of coal in the Inland Basin coal beds. The overlying layers of rock are stripped away and flat-lying coal layers are mined directly at the surface or outcropping.

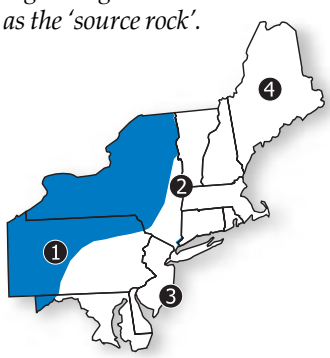
see Non-Mineral Resources, p.162, for more on **anthracite.**

Coal is used for more than just heating and generating electricity. It is also used in plastics, synthetic rubber, fertilizer, cosmetics, medicine, paint and dyes. Additionally, bituminous coal is important in the steel and glass industry coking process in which bituminous coal is heated to very high temperatures in a low-oxygen environment. The result is a residue of fused carbon and ash used in blast furnaces.

Coal, oil and gas are all made of organic matter. The differences in the kinds of organic matter determine which type of fossil fuel is formed. Coal tends to be formed from land plants, accumulating in swampy areas. Oil, on the other hand, is made primarily of phytoplankton, bacteria and plant material from the ocean. Coal remains solid because of the nature of the land plant material, whereas the marine organic material transforms under high heat into oil and natural gas. Natural gas, primarily made of methane, forms either alone or in association with coal and oil, when high temperatures transform solid organic material to a gas.

Unlike coal, which forms and stays in one place, oil and gas form in one place and then migrate to another. Organic material from marine plants and animals becomes buried under increasing amounts of sediments that squeeze and heat up the organic material over time. The sediments containing the organic material eventually become ***sedimentary rock***, commonly shale. The oil and gas generally do not stay in the rock that originally contained them because they tend to migrate upwards through cracks and permeable rocks to the surface where there is less pressure. If the oil and gas reach the surface, they evaporate into the atmosphere or are broken down chemically. However, if they are somehow trapped below the surface, the oil and gas pool within the rock. An impermeable

The **sedimentary rock** *containing the organic material is known as the 'source rock'.*



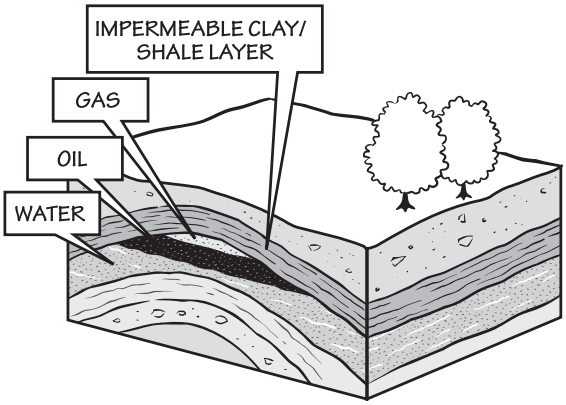


Figure 7.5: Folds act as traps for oil and gas. Figure by J. Houghton.

layer, such as shale, is what halts the oil and gas ***migration*** to the surface. To pool the fossil fuels, in addition to an impermeable layer, a trapping mechanism is necessary. Folds or faults in rock layers are common trapping mechanisms *(Figure 7.5)*.

The rock to which the oil and gas **migrate** *is called the reservoir rock.*

Permeable vs. impermeable rocks

Rocks that are permeable allow fluids and gas (such as water, oil and natural gas) to move through the rock. Fractures within the rock and spaces between the grains of a rock are pathways for fluids and gas. Sandstone, limestone and fractured rocks generally are permeable rocks. Shale, on the other hand, is usually impermeable because the small, flat clay particles that make up the rock are tightly packed into a dense rock with very little space between particles. Poorly sorted sedimentary rocks may also be impermeable because the smaller grains fill in the spaces between the bigger grains, restricting the movement of fluids and gas (Figure 7.6).

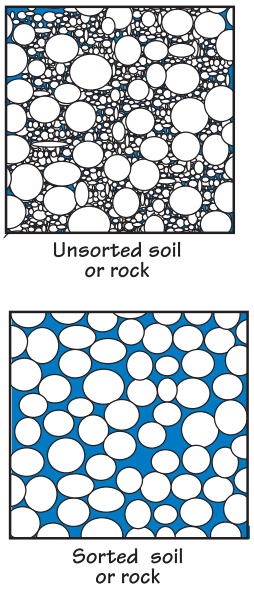
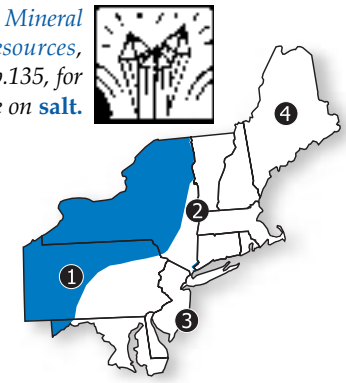


Figure 7.6: Sorted and unsorted soil or rock affects porosity and permeability.

The Inland Basin has the combination of features necessary for the formation and trapping of oil and gas. The source of the oil and gas in the Inland Basin is the accumulation of dead plants, animals, phytoplankton and bacteria that were deposited on the floor of the inland ocean and buried by sediments. As the organic material was increasingly more deeply buried, it was squeezed and heated to become oil and gas and subsequently migrated upwards. The Devonian Oriskany Sandstone, a well-sorted sandstone that has excellent permeability and that is overlain by an impermeable layer, has provided a reservoir rock in which oil and gas pooled. The gentle folds of the region, formed during the Paleozoic mountain-building events, are excellent traps for oil and gas. The layers of ***salt*** found beneath Devonian rocks were instrumental in the folding of the overlying rock layers. Layers of salt beneath the surface are easily deformed by the weight of overlying rocks. Just as oil and gas try to migrate upward, so do layers of salt. As salt pushes upward, it warps and folds the overlying rocks. The folds provide traps for the migrating oil and gas.

The **salt** *in the Inland Basin region was deposited during the Silurian when shallow water and poor circulation caused the evaporation of water and precipitation of layers of salt.*

see Mineral Resources, p.135, for more on **salt.**



Non-Mineral Resources

The oil industry got its start in the Inland Basin. In 1859, Colonel Edwin Drake drilled the world's first commercial oil well in Titusville, Pennsylvania. Though the amount of oil produced in Pennsylvania is small, it is high grade and thus relatively valuable. Though there are several oil fields in southwestern New York, very little oil is produced there *(Figure 7.7)*.

The natural gas industry in the United States also got its start in the Inland Basin. In 1821 in Fredonia, New York, William Hart drilled the first natural gas well. The potential of natural gas as a fossil fuel was not recognized, however, until the early 1900's. In the past, natural gas was released into the air from coal mines and oil wells. Now that gas is a frequently used fossil fuel resource, it is no longer released to the atmosphere. Rock units that were sources of natural gas in the past are now used in many places throughout New York and Pennsylvania as underground gas storage. Gas is pumped into the rock in summer, and removed in winter for use as heating fuel.

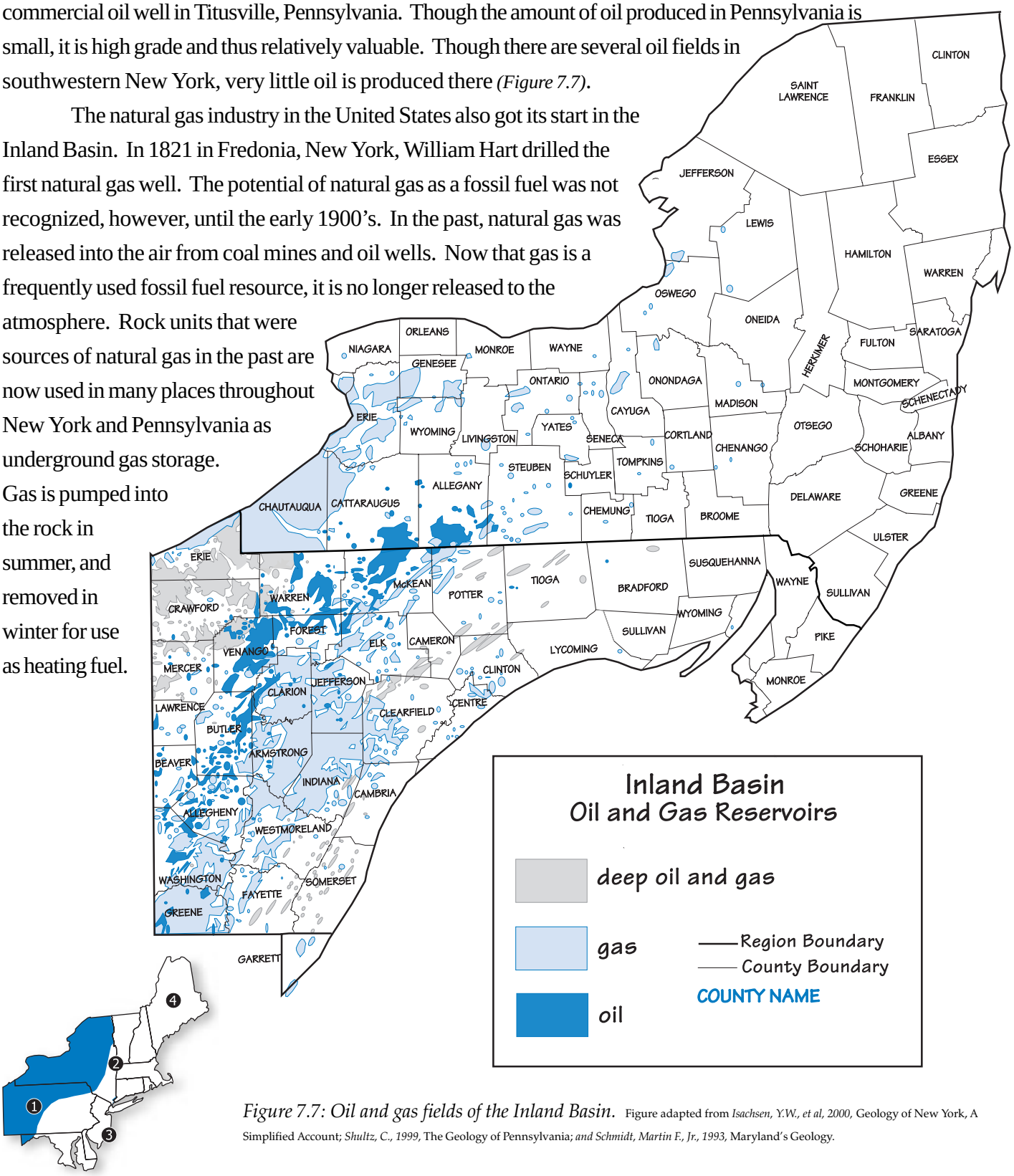


Figure 7.7: Oil and gas fields of the Inland Basin. Figure adapted from *Isachsen, Y.W., et al, 2000,* Geology of New York, A Simplified Account; *Shultz, C., 1999,* The Geology of Pennsylvania; *and Schmidt, Martin F., Jr., 1993,* Maryland's Geology.

Non-Mineral Resources of the Appalachian/Piedmont

Region 2

The Appalachian/Piedmont region has a diverse assortment of non-mineral resources because of the diverse rocks in the region *(Figure 7.8)*. The sedimentary rock non-mineral resources include the brownstone of the Triassic Rift Basins, as well as clay, lime, crushed stone and industrial sand. Diabase is an igneous rock resource. Metamorphic rocks, such as marble, the serpentinite of the Ultramafic Belt, and slate, are important to the regional economy. Additionally, the Appalachian Piedmont has the fossil fuel anthracite, a form of coal.

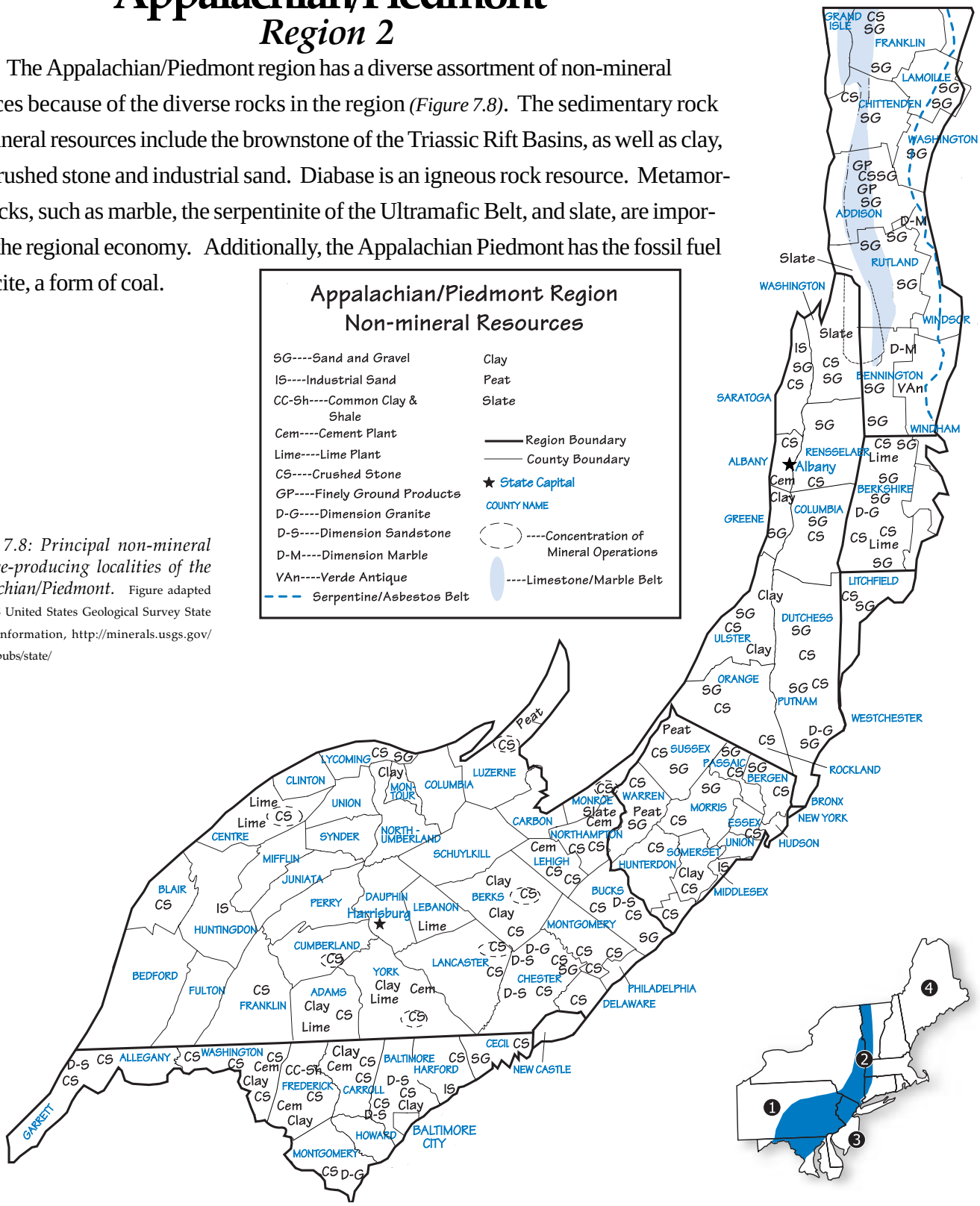


Figure 7.8: Principal non-mineral resource-producing localities of the Appalachian/Piedmont. Figure adapted from 1998 United States Geological Survey State Mineral Information, http://minerals.usgs.gov/minerals/pubs/state/

Non-Mineral Resources

Sedimentary Rocks

The most distinctive sedimentary rock of the Appalachian/Piedmont region is brownstone, a red to brown sandstone found in the Triassic rift basins of southeastern New York, New Jersey, Pennsylvania and Maryland. As the united continents of Pangea began to break apart during the Triassic and Jurassic, the crust rifted and cracked. Blocks of crust slid downward to produce the rift basins that gradually filled in with sediment. Because of the position of North America with respect to the equator, the Northeast climate was warm and dry. The arid climate and the oxidation of iron in the sediments produced red to brown sedimentary rocks locally known as 'brownstone.' The fine polish of brownstone made it a popular building and decorative stone that has been used throughout the Northeast, especially in New York City.

see Geologic History, p.16, for more on **rift basins.**

see Rocks, p.45, for more on **the color of rocks.**

Clay, lime, and crushed stone of various rock types are also used in production of cement. Lime, originating from ***limestone, dolostone*** or ***marble***, has a variety of uses in construction, the chemical industry and manufacturing of concrete and cement. Lime is very important to agriculture, where it is regularly applied to make the soils 'sweeter' or less acidic. Additionally, industrial sand is mined from crushed sandstone and quartzite, as in the Inland Basin Region.

Limestone and dolostone *are both carbonate rocks formed from calcium carbonate and calcium magnesium carbonate respectively.* **Marble** *is metamorphosed carbonate rock.*

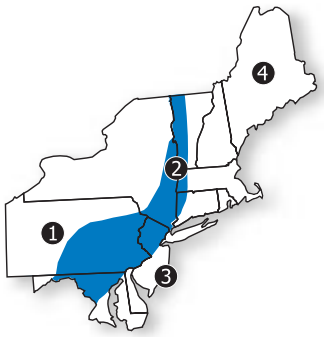
Chester and Lancaster Counties in Pennsylvania have some of the best farmland in the country because of the lime-rich soils resulting from the underlying limestone.

Igneous Rocks

The igneous rock non-mineral resources in the Appalachian/Piedmont region are limited to diabase, formed from magma close to the surface pushing its way through the sediments of the Triassic rift basins. Locally known as 'traprock', diabase has the same composition as basalt. Diabase, however, cooled somewhat more slowly beneath the surface, allowing time for formation of visible crystals. Diabase is commercially called 'black granite,' and thus is listed in Figure 7.8 as dimension-granite in Pennsylvania. It is used as a building stone and facing.

Metamorphic Rocks

There is a wide array of metamorphic rocks in the Appalachian/Piedmont region that are important as non-mineral resources, including marble, serpentinite, slate, and emery. The Marble Valley, stretching from Vermont into western Massachusetts and Connecticut, is the focus of marble quarrying today in the Northeast. Proctor, Vermont, home of the now defunct Vermont Marble



Company, was the center of Vermont marble production. Quarrying of marble has significantly declined in the last few decades, as synthetic materials have begun to replace it for many purposes.

The formation of the Marble Valley dates back to the ***Taconic*** mountain-building event. As limestone was deposited along the continental shelf in the Iapetus Ocean during the Cambrian, the Taconic volcanic islands and Baltica were approaching from the east. As the approaching volcanic islands compressed the limestone, it was metamorphosed to become marble. The earliest 'marbles' quarried were at Isle LaMotte in the Champlain Islands of Vermont because it was easy to transport the marble down Lake Champlain. The islands were a natural place for the development of the marble industry in the Northeast. Technically, though, the Lake Champlain Islanders were quarrying limestone, as the rock had not been metamorphosed enough to be considered a ***true marble***. It is quarried today under the name 'Champlain Black,' which signifies the black color of the Chazy Limestone.

The slate belt of Vermont and New York is immediately west of the Marble Valley. Slate, which is mildly metamorphosed shale, is used for roofing, flagstones, floor tiles, blackboards and pool tables. In a process similar to the formation of marble in the Marble Valley, the slate formed from Cambrian and Ordovician sediment (in this case, shale) deposited on the seafloor was metamorphosed to slate during the subsequent mountain-building events. More extreme metamorphism than seen in slate resulted in the 'emery rock' found in New York in the Manhattan Schist. Emery, an intensely metamorphosed rock made of magnetite, corundum, sillimanite, sapphirine and cordierite, is used as an abrasive for grinding and polishing. Emery is no longer mined in the Appalachian/Piedmont, because synthetic abrasives, less expensive to produce, have replaced it. At one time, though, emery was an important natural resource of the region.

Danby, Vermont is now the center of Vermont marble production.

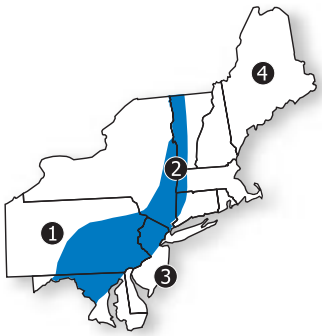
Beautiful, crystalline marble takes a fabulous polish, and is thus commonly used as a decorative stone for buildings, monuments, interior facings and countertops. Crushed marble is useful as a filler, food additive and paper coating.

see Geologic History, p.7, for more on **Taconic events.**

Marble?

Not everything commercially called a marble is a **'true'** ***marble,*** *which lacks fossils and is recrystallized from limestone. The limestone in northwestern Vermont was only very weakly metamorphosed, if at all. Actual marble is found between Manchester and Middlebury Vermont, and parts of western Massachusetts and Connecticut. Green serpentinite rock from the Ultramafic Belt is also quarried and sold as a marble under the name Verde Antique. Serpentinite is hardly a marble. It was formed from the metamorphism of slices of oceanic crust and upper mantle that were scraped off of the oceanic plate being subducted beneath the North American continent during the Ordovician. The Ultramafic Belt, stretching the length of the Appalachian Mountains along the Taconic volcanic island suture zone, also has concentrations of the soft rock soapstone, made primarily from the mineral talc (Figure 7.9).*

Figure 7.9: Ultramafic Belt in the Appalachian/Piedmont.



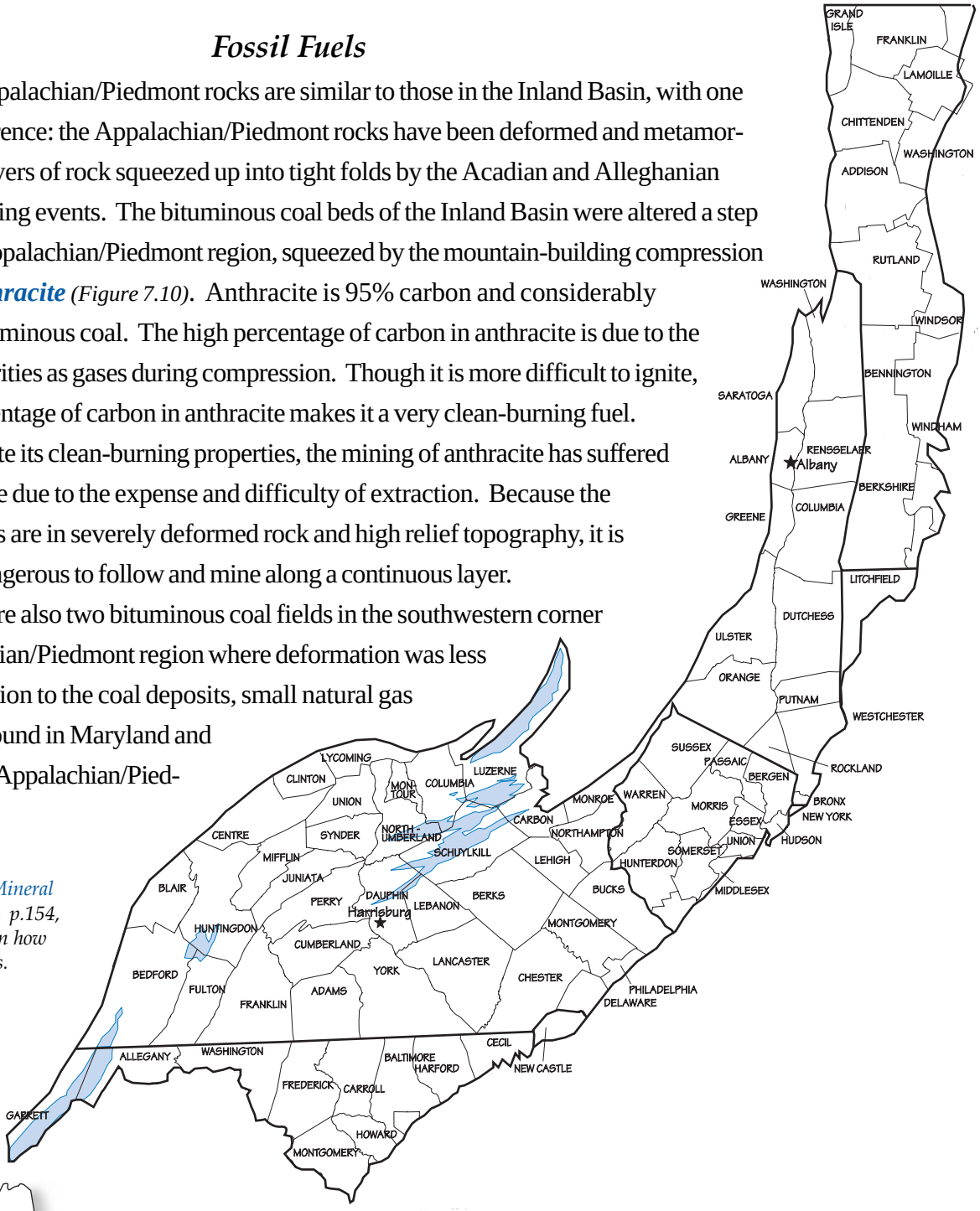
Non-Mineral Resources

Fossil Fuels

The Appalachian/Piedmont rocks are similar to those in the Inland Basin, with one important difference: the Appalachian/Piedmont rocks have been deformed and metamorphosed, with layers of rock squeezed up into tight folds by the Acadian and Alleghanian mountain-building events. The bituminous coal beds of the Inland Basin were altered a step further in the Appalachian/Piedmont region, squeezed by the mountain-building compression to become ***anthracite*** *(Figure 7.10)*. Anthracite is 95% carbon and considerably harder than bituminous coal. The high percentage of carbon in anthracite is due to the release of impurities as gases during compression. Though it is more difficult to ignite, the higher percentage of carbon in anthracite makes it a very clean-burning fuel. However, despite its clean-burning properties, the mining of anthracite has suffered a serious decline due to the expense and difficulty of extraction. Because the anthracite layers are in severely deformed rock and high relief topography, it is difficult and dangerous to follow and mine along a continuous layer.

There are also two bituminous coal fields in the southwestern corner of the Appalachian/Piedmont region where deformation was less severe. In addition to the coal deposits, small natural gas reservoirs are found in Maryland and Pennsylvania's Appalachian/Piedmont region.

see Non-Mineral Resources, p.154, for more on how **coal** *forms.*



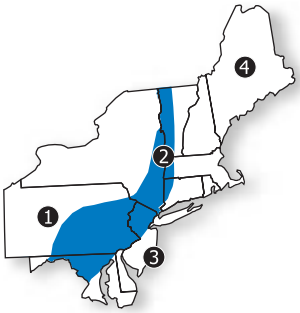


Figure 7.10: Anthracite coal fields of the Appalachian/Piedmont. Figure adapted from *Isachsen, Y.W., et al, 2000,* Geology of New York, A Simplified Account; *Shultz, C., 1999,* The Geology of Pennsylvania; *and Schmidt, Martin F., Jr., 1993,* Maryland's Geology.

Non-Mineral Resources of the Coastal Plain

Region 3

The primary non-mineral resources of the Coastal Plain are the layers of sand and gravel eroded from the Appalachian Mountains to the west *(Figure 7.11)*. Greensand and diatomaceous earth were also at one time important resources. Since the region does not have solid rock and is composed entirely of layers of loose ***sediments***, the Coastal Plain does not have the same kinds of resources that are abundant in the other regions.

see Rocks, p.46, for more on the Coastal Plain **sediments.**

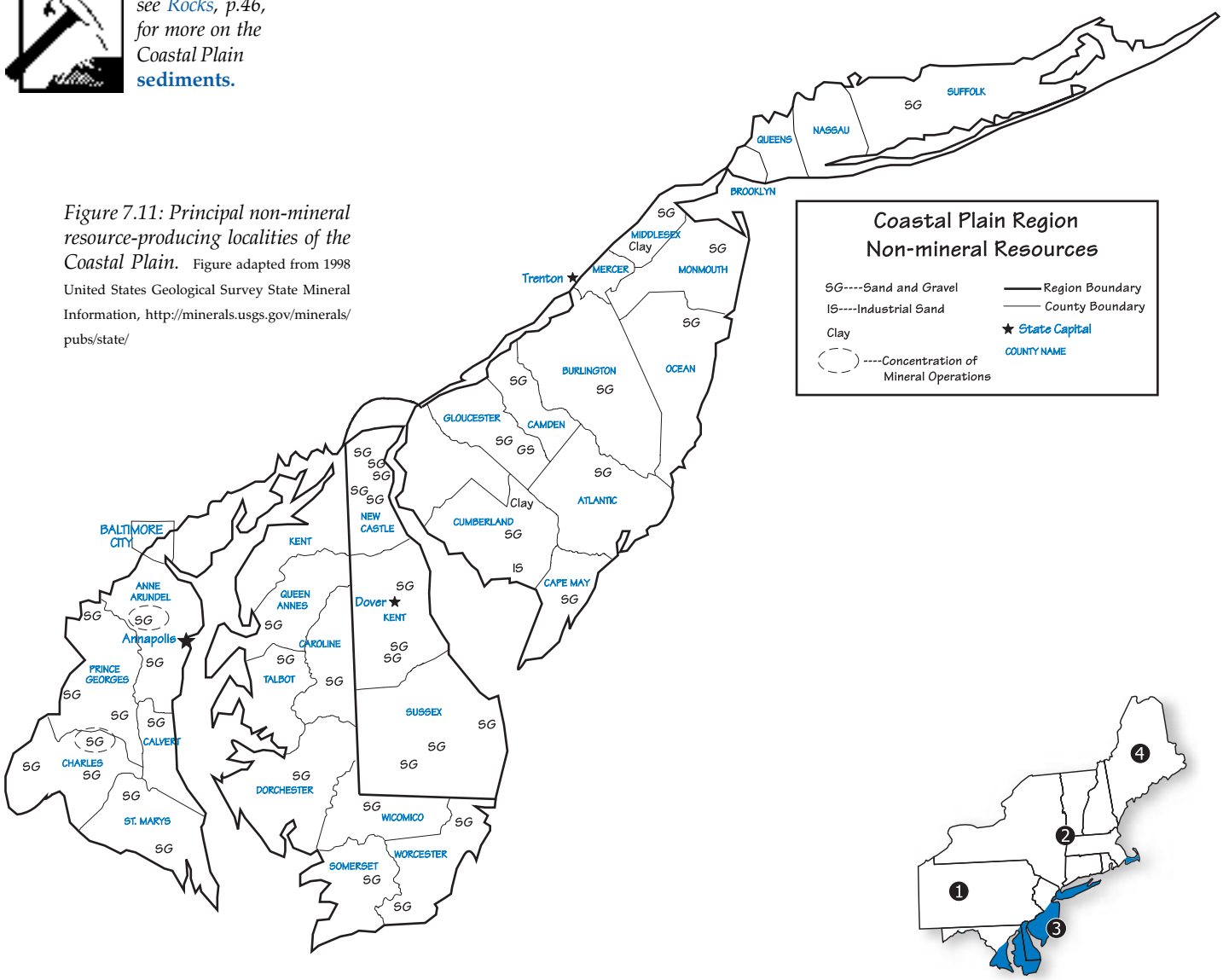


Figure 7.11: Principal non-mineral resource-producing localities of the Coastal Plain. Figure adapted from 1998 United States Geological Survey State Mineral Information, http://minerals.usgs.gov/minerals/pubs/state/

Non-Mineral Resources

Sediments

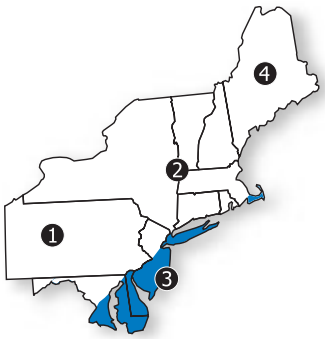
Sand and gravel, eroded from the Appalachian Mountains to the west, are easily accessible, extremely abundant and useful natural resources in the Coastal Plain region. Due to the nature of the Coastal Plain, which is loose sediment and not rock, sand and gravel deposits are plentiful and easily mined. Sand and gravel are primarily used in construction, concrete and road fill. Industrial sand, mined in Cumberland County, Maryland, has a slightly different nature than ordinary sand and gravel. Important for its predominantly quartz content, industrial sand is used in sandblasting, filtering and in the manufacture of glass.

Greensand, containing the relatively common Coastal Plain mineral glauconite, is still used today as a soil conditioner and water softener. It also has potential for use in landfills and as a filter for heavy metals from industrial wastes. ***Diatomaceous earth*** from the Maryland Calvert Formation was at one time an important natural resource for Maryland (and the only place in the United States where it was mined). Made of the hard shells of microscopic marine organisms, known as diatoms, diatomaceous earth is used in filtering and as an abrasive.

Diatomaceous earth *is used today in swimming pool filter systems.*

Soil

The soil of the Coastal Plain developed on the already loose, unconsolidated layers of sediment that make up the region. As there is no hard, cemented rock, soil forms much more easily and quickly in the Coastal Plain than in other regions of the Northeast. In most areas of the Coastal Plain, the soil for agriculture is an excellent mix between sand and clay, with the sand providing good drainage. Areas that are too clay rich have poor drainage due to the impermeable nature of clay. Depressions in the landscape or areas of slightly lower topography in the Coastal Plain often remain too wet and are not good areas for cultivation of crops.



Non-Mineral Resources of the Exotic Terrane

Region 4

The Exotic Terrane region has a variety of non-mineral resources, many similar to those of the Appalachian/Piedmont region because of the rock types these regions share. Coal is even found in the Exotic Terrane region in the Narragansett and Boston basins, though it is not currently mined *(Figure 7.12)*.

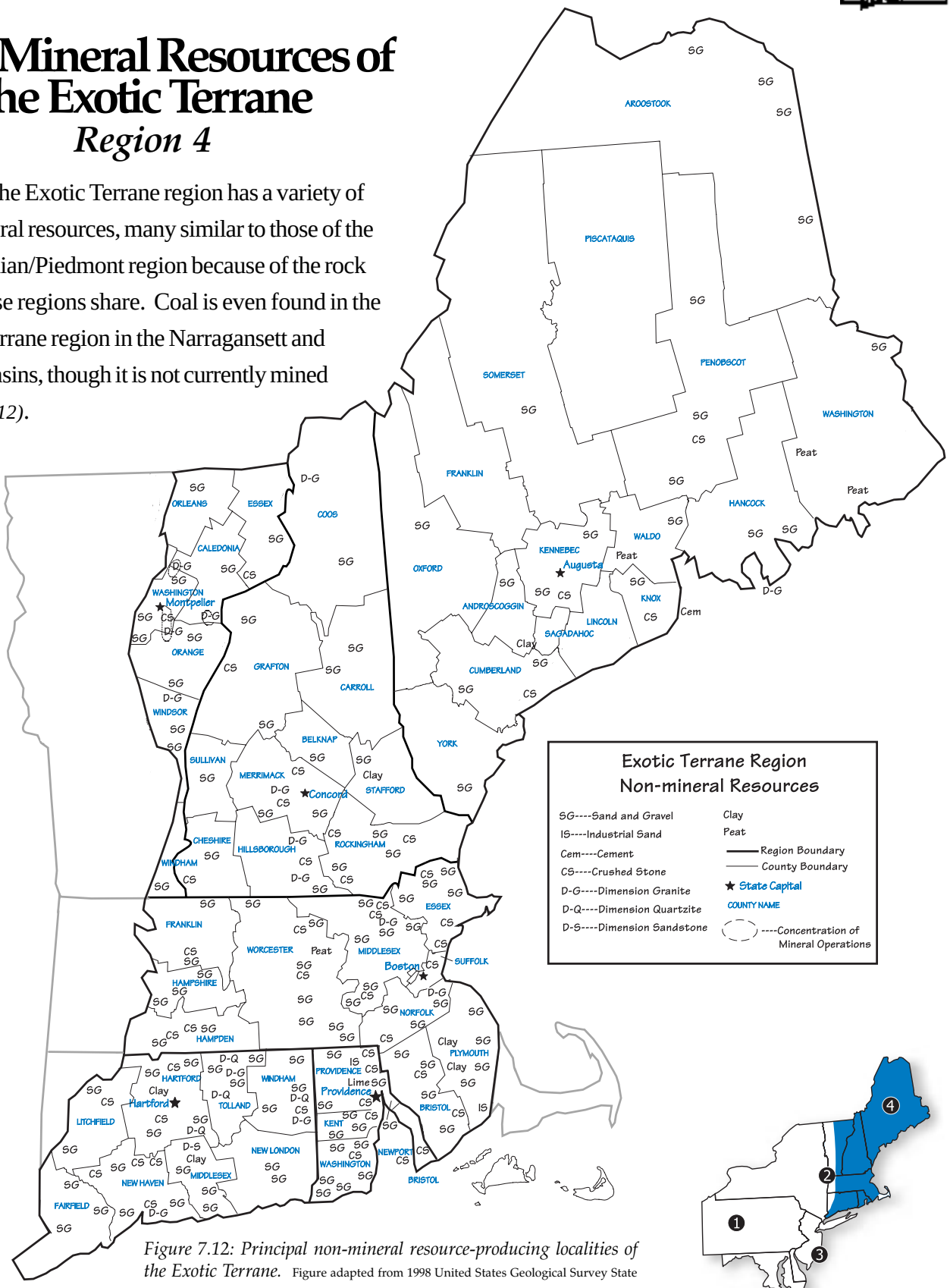


Figure 7.12: Principal non-mineral resource-producing localities of the Exotic Terrane. Figure adapted from 1998 United States Geological Survey State Mineral Information, http://minerals.usgs.gov/minerals/pubs/state/

Non-Mineral Resources

Sedimentary Rock

The sedimentary rock non-mineral resources of the Exotic Terrane are similar to those of the Appalachian/Piedmont and Inland Basin regions. Brownstone is quarried from the ***rift basin*** in the Connecticut River Valley; clay and shale are mined from glacial deposits and marine shales of the Silurian and Devonian; and cement and crushed rock are produced from a variety of rock types to be used in the construction industry.

see Non-Mineral Resources, p.160, for more on **rift basin** *resources.*

Igneous Rock

Granites, formed from intrusions of magma during the Taconic and Acadian mountain-building events, appear all over the Exotic Terrane region. It is quarried throughout the region for use in buildings and monuments, though the demand is not as great as it was in the past. Granite is more expensive to quarry than the much softer marbles found in Vermont, and the issue of transportation raises costs even higher. Though New Hampshire is known as the Granite State for its abundance of granite of varying ages, Barre, Vermont is known as the granite center of the world. The famous ***Barre Granite***, formed from an intrusion of magma into overlying rock during the Acadian mountain-building event, is a uniform light gray that takes an excellent polish and is widely used for monuments.

see Geologic History, p. 7 and 12.

see Rocks, p.51, for more on the **Barre Granite.**

Barre, Vermont is the home of the famous Rock of Ages Quarry, which quarries the **Barre Granite.**

Metamorphic Rock

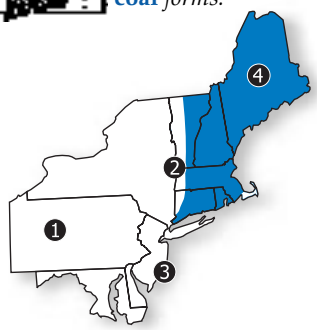
Quartzite is being actively quarried from Silurian and Devonian metamorphic rock in Connecticut. Quartz is derived from sandstone deposited in the Iapetus Ocean. The sandstone became compressed, metamorphosed and attached to the continent when Baltica collided with North America. When sandstone is metamorphosed, it recrystallizes to become ***quartzite***.

Quartzite *is quarried for use as a building and decorative stone.*

Fossil Fuels

Coal is found in the Narragansett Basin of Rhode Island and Massachusetts. The coal was formed during the Pennsylvanian when the collision of North America and Baltica compressed the Avalonia microcontinent caught in the middle. The collision buckled the crust to form small basins that gradually filled in with sediment. Accumulations of dead plant material in the swampy basins provided the proper conditions for minor amounts of bituminous coal to form, though there are not large enough amounts to make mining profitable.

see Non-Mineral Resources, p.156, for more on how **coal** *forms.*



Glacial Deposit Resources
of the Northeast

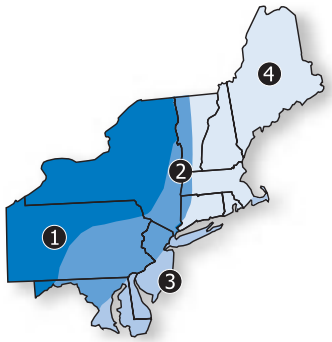
All four regions of the Northeast share a common source of non-mineral resources: the deposits left by glaciers of the most recent ice age. For the last 1.8 million years, a continental ice sheet originating in northern Canada has advanced and retreated over North America. Around 20,000 years ago, a warming climate put the glaciers in retreat, bringing the Northeast to its current interglacial period. Deposits associated with the massive, moving and melting ice remain today as valuable non-mineral resources in the Northeast. The glaciers covered the northern parts of all four regions of the Northeast as far south as northern Pennsylvania, New Jersey and Long Island.

see Glaciers, p.64.

The main non-mineral resources resulting from the last glacial advance are clay, peat, soil, sand and gravel. As the glaciers moved over the surface of the Northeast, they scraped and gouged the landscape. The numerous lakes dotting the Northeast resulted from the vigorous scouring activity of the glaciers. Much of the clay mined today in the Northeast comes from the bottom of these glacier-formed lakes. Used in bricks and pottery, the glacial clays are an important natural resource of the Northeast. Clay is also commonly used in place of heavier stone and gravel to make a lightweight concrete. As the glacial lakes filled and later drained to become bogs and swamps, organic material accumulated at the bottom. Bogs and swamps are ideal environments for the accumulation of dead plants. Kept wet and buried by more dead plant material, the stagnant water of a bog provides little if any oxygen for bacteria to completely decompose the plant material as it would on the forest floor or in a flowing stream. The resulting peat, a precursor to coal, is mined and used as mulch and as a soil conditioner.

The glaciers also left deposits on the surface on which the Northeast ***soils*** have developed. In combination with the underlying bedrock, the glacial deposits contribute good and bad characteristics to the soil (from the perspective of cultivation). Till, the unsorted mix of sand, silt, clay and gravel that was deposited by melting glaciers, developed into impermeable soils that cannot properly drain water. The unsorted material has no spaces between particles, leaving nowhere for water to drain. Likewise, clay deposits from glacial lakes are also impermeable, being uniformly composed of very small, flat clay particles. Glacial outwash

Soil *is an important natural resource because the cultivation of crops is dependent on soil type.*



deposits of sand and gravel, on the other hand, are generally well sorted and thus well-drained.

The soils developed in the Northeast are a direct result of the underlying rock type and transported glacial sediment. Glacial clay, till, sand and gravel blanket much of the region and affect the permeability of soil. Also, the reason why New Englanders find so many rocks in their farms and gardens is because the glacial till became incorporated into the soil. The till has since become incorporated into the famous stone walls of New England.

Perhaps the most important resource left to the Northeast by the glaciers is sand and gravel. Dominating the natural resource economies of many of the Northeast states, sand and gravel is an extremely abundant, easily mined natural resource of the area. Naturally broken rock the size of sand and gravel was dumped all over the Northeast landscape by the glaciers. As the glaciers advanced over the landscape, their vigorous scraping action incorporated boulders, gravel, sand, silt and clay from the underlying bedrock and already loose sediment into the moving ice. Each time the glaciers stopped moving forward or backward, melting ice deposited drift and till in front of and to the sides of the glacier, creating mounds (called moraines) of sand and gravel. Significant ***deposits*** of sand and gravel were produced by deltas formed by glacial streams and in valleys filled by retreating glaciers. Sand also accumulated in snake-like tunnels beneath the ice, in which sand was deposited by flowing subglacial streams; these sinuous deposits of sand are called eskers. Glacial sand and gravel are easily mined because the glacial deposits are all at the surface and there is little if any processing involved. Sand and gravel composed of chunks of limestone, dolostone, sandstone, metamorphic and igneous rocks are mostly used for construction purposes. Shale and siltstone, being softer rocks, are generally too weak for construction, and are more often used together with lime in making concrete.

see Glaciers, p.61, for more on glacial **deposits.**