INTRODUCTION TO GEOLOGICAL PROCESS IN ILLINOIS

ECONOMIC GEOLOGY

INTRODUCTION

Since pre-historic time, the rocks and minerals of Illinois have been used by humans. By exploring these useful geologic resources, geologists have been able to learn how and why they form and where other, similar geologic resources are likely to be found. Whether or not a resource will be exploited depends on the value of the resource versus the cost of extracting, refining, and delivering the resource. Important geologic resources include fluorite (the state mineral), galena, sphalerite, silica, peat, coal, limestone, clay, chert, and sand. Extraction and use of these geologic resources have both positive and negative impacts on society and the environment.

GEOLOGIC RESOURCES

The United States Geological Survey (USGS) defines a resource as: "A concentration of naturally occurring, solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible." More simply, a resource is something in the Earth that is (or could be) useful to humans and could be extracted and sold for a profit now or sometime in the future. This definition is very broad and encompasses a wide variety of earth materials; what excludes many substances from the USGS definition is economic feasibility.

Consider the following list. Which items are resources?

- a vein of gold
- a rock with 0.001% gold
- gold dissolved in sea water (0.000004 parts per billion)
- a one-foot thick seam of coal 500 feet below the ground surface
- a six-foot thick seam of coal 500 feet below the ground surface
- a six-foot thick seam of coal 30 feet below the ground surface

Resource Economics

It can be tricky to determine what is and what is not a resource. In fact, the definition for each substance is different and changes over time with changes in technology and consumer demand. While a complete lesson in economics is not appropriate here, a few definitions and examples should help clarify the topic.

First, a few terms:

Resource: as stated above, a geologic resource is an earth material that is useful to humans and could be extracted and sold for a profit now or sometime in the future.
Reserve: the identified and measured portion of a resource that can be extracted and sold for a profit now.
Ore: rocks or minerals containing metallic minerals that can be mined and extracted at a profit.

These definitions are all influenced by the technological ability to extract the material and by the material's value. The ability to extract the material is based on technology. The status of materials that were not considered resources in the past can change because scientists and engineers may develop new ways to use them or better methods to extract them. The material's value is also based on supply (how much is available) and demand (how much is wanted). As demand increases, the value of the resource increases; as a result, money becomes available to develop new technology to extract the material and to exploit deposits that cost more to extract. The diagram below shows the relationship between different types of resources and reserves.

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred		
SUBECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		
Other Occurrences	Includes nonconventional and low-grade materials				

(This table was copied from United States Geological Survey Circular 831, "Principles of a Resource/Reserve Classification for Minerals.")

The left column indicates whether or not the material can be extracted at a profit (economic). As technology develops and demand for a material changes, a deposit of the material may move up or down on this diagram. The categories from left to right indicate certainty of presence of the material. The more certain geologists are of the presence and quantity of a resource, the farther to the left it is placed; over time, resources move from the right to the left as they are identified and measured.

The term ore is used to identify a rock that would be a reserve of a metallic mineral. The same restrictions of technology and demand applied to the term reserve apply to the term ore. For example, today iron ore must contain at least 25% iron and aluminum ore at least 35% aluminum; however, gold is so valuable, that gold ore may contain as little as 0.0008% gold.

Returning to the list above, all of the examples are geologic resources because they are known and *could* be extracted (although not all for a profit at present). However, not all are considered reserves because they are not all economic; for example, the gold in seawater is not in a high enough concentration and the one-foot thick coal seam is too thin. With respect to the other examples, there is not enough information to determine whether or not the resource is economically viable.

Some questions that would need to be answered would include:

- gold: How deep is the deposit? How large is the deposit?
- coal: What is the quality of the coal? (including heat given off per pound and the presence of impurities such as sulfur) Is there access to a market?
  assessing coal resources: http://energy.usgs.gov/factsheets/nca/nca.html

Geology of Economic Resources
In order to be economic, a resource must be a concentrated form of the desired material. Many geologic processes can concentrate materials that are useful to humans. These concentrations can be located by geologists based on an understanding of the process that produce them. General descriptions of some of these processes are given below.

Igneous rocks are produced by the solidification of molten rock. Igneous rock is very durable, and the unrefined rock is a resource used as building material. Igneous processes can result in the concentration of desirable elements and minerals. Molten rock may contain very small concentrations of many resource materials; however, unless they become concentrated, they will not be economically important. The following are some examples of igneous processes that can result in economic deposits:

> *Layered intrusions* occur when a large igneous intrusion cools very slowly. During the cooling process, mineral crystals form and settle to the bottom of the intrusion. Because each mineral has a unique temperature of crystallization, different crystals form and settle at different times during the cooling process, resulting in layers that may have economic concentrations of some minerals.
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> *Pegmatite intrusions* occur late in the cooling process. Molten rock contains water; as other minerals crystallize, the proportion of water in the molten rock increases. The high concentration of water inhibits the formation of new mineral crystals; the crystals that do form act as “seeds” and can grow very large. A vein of these large crystals is known as a pegmatite. Pegmatites are often the source of mineral specimens found in collections and used in classrooms.
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> *Hydrothermal activity* affects the rocks surrounding the intrusion. Molten rock contains hot water and can heat water contained in the surrounding rock. The hot water can react with minerals in the rock and dissolve some of them. If the water moves away from the intrusion carrying the dissolved minerals, the minerals can be deposited in other locations as the water cools or dissolves new minerals and leaves others behind.

Metamorphic rocks are produced from the alteration, while in the solid state, of existing rock due to heat, pressure, or both. Some metamorphic rocks are very durable and the unrefined rock is used as building material. The metamorphic process involves several aspects which produce economic resources.

> *Compaction* and *crystal growth* produce dense rocks useful as building materials.
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> *Foliation* results when minerals form and align due to high pressure. Foliation in low grade metamorphic rocks results in slaty cleavage, where the rock breaks into thin sheets. Slate is used as paving stones, for pool table tops, and as roofing material.
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> *New crystals* form that are stable at high pressures and temperatures. This can result in a rock that has a high concentration of a resource mineral such as talc or asbestos.

Unconsolidated sediment deposits are created by the erosion, transportation and deposition of weathered rock material, and by biological processes. The processes that produce these deposits often sort the sediment and leave economic concentrations of geologic resources.

Weathering occurs when earth materials are exposed to water and air. The weathering process can remove and alter some minerals and leave others behind. The result of this activity can be the concentration of minerals left in their original location or of those that are moved. Bauxite, an aluminum ore, is left behind when water dissolves and removes other minerals that were in the soil.

Moving water and wind pick up and drop off minerals based on their size and weight. This process results in placer deposits of economic minerals such as gold, which is heavy and is dropped when the water begins to slow, as well as sand, gravel, and clay.

Biological activity can result in deposits of organic material such as peat, which is left behind when plants die in a swamp, and deposits of animal waste, such as guano (bird or bat droppings, which has high concentrations of phosphorus.

Sedimentary rocks are produced when sediments are compacted and cemented. As with the other rock types, some sedimentary rocks are very durable, and the unrefined rock is a resource used as building material. The sedimentary process also results in concentrated deposits of economic materials in specific environments of deposition.

Biological activity can result in deposits rich in organic material such as coal, oil, and natural gas, and deposits rich in shell material such as limestone and chert.

Moving water and wind sort the sediments by size, resulting in concentrated deposits of gravel, sand and clay.

Chemical precipitation from the water can leave behind minerals such as gypsum, halite (rock salt), calcium carbonate, and, very early in the Earth's history, iron.

Geologists who explore the Earth to find these materials do so on the basis of the processes that produce them. Until these processes were understood, earth materials were mined only where they were found exposed at the surface. The driving force behind the development of geology as a science was, in large part, a quest for valuable rocks and minerals.

Resource Development
In order to use a resource, it must be located, extracted, and refined for use. All three steps involve geologists.

1. **Explorations** for geologic resources are based on a knowledge of the processes that produce those resources. Exploration begins by examining existing geologic maps or creating new maps to locate areas where a resource might occur. A field geologist will then visit the area and collect samples, drill holes, or use geophysical techniques that allow examination of the subsurface. Once a resource is located, its extent and quality are examined and suitability for mining is determined.

2. **Extraction** techniques are based on the characteristics of the resource being extracted. The most common methods are as follows:

    Strip or open-pit mining is used when the resource lies relatively close to the surface. Overburden is removed from the top of the resource and the rock is then excavated and hauled away for refining.

Underground mining is used when there is too much overburden or when the resource is confined to a relatively small area such as a vein. The resource and as little of the surrounding rock as possible are extracted leaving an open space in the ground which may be supported by pillars of the resource rock that were not removed. Some mining operations remove all of the resource rock and allowed the remaining open space to collapse. After mining, the resource material is then hauled away for refining.

Pumping is used primarily for liquid and gas resources such as oil and natural gas (methane), but may also be used to extract resources that dissolve easily such as salt. A hole is drilled into the resource, and, as in the case with oil and natural gas, the resource is pumped out (if it is under very high pressure, it may flow out on its own). To extract salt, water is pumped down the well to dissolve the salt and the salty water is pumped out. The resource is then taken away for refining.

3. **Refining** is the process or processes that prepare the resource for use. Some geologic resources may need very little refining, while others may need a lot. Some examples of refining processes are:

Building stone: The rock is cut into blocks and may be polished.

Sand and Gravel: The sediment is sorted, washed, and placed into piles according to size.

Cement: Limestone is crushed, mixed with clay, cooked, and crushed to a powder.

Lead: The mineral galena (PbS) is heated until the sulfur is vaporized and the lead melts; the molten lead flows to the bottom of the smelter where it is collected and cooled.

Gold: Low concentration gold ore is crushed, the crushed material is placed in a pile which is sprayed with liquid cyanide, as the cyanide seeps through the crushed ore, it dissolves the gold, the gold/cyanide solution is collected and the gold is removed.

The amount and complexity of refining is based on the technology available and the value of the resource. A producer can not afford to spend very much money refining a low-value resource like sand and gravel; however, at a gold mine, even the water from the miners' shower room is collected and refined.

Effects of Resource Use

The use of geologic resources has many effects. The positive effects are apparent all around us. A very useful exercise is to look around the room and list the things you see that were produced using resources from the Earth.

Our reliance on geologic resources also impacts society and the environment. None of the Earth's resources are evenly distributed, which means that people around the world must interact and trade resources. The positive result has been a mixing of cultures and exchange of wealth. Unfortunately, not everyone agrees with how resources should be used, who should use them, or how much they should cost; the consequence has been conflicts throughout human history.

Geologic resources are considered non-renewable because they are extracted faster than natural processes replace them. As humans mine each resource, they can expect to have removed all of it at some time in the near or distant future. If the resource is consumed by use, such as gasoline and coal, it is gone forever. However, if it is not consumed by use, such as glass, metal, and plastic, it can be recycled and used again, preserving the in-ground resource.

Development of a resource for human use can have a great impact on the Earth. The impact can be placed in three categories:

> *Exploration* for geologic resources usually has a relatively small impact. Drill holes and roads are the primary impacts.
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> *Extraction* usually has a large impact. Strip/open-pit mining is especially destructive because the land surface is completely disrupted. Underground mining and pumping have less impact, but often, as the resource is removed, the loss of support for the overlying rocks results in subsidence (sinking) of the ground surface.
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> *Refining* is usually somewhere in between extraction and exploration. In the past, refining operations caused a lot of pollution because the waste materials were dumped nearby or went into the atmosphere. Modern refining operations are much more efficient and produce less waste, much of which is returned to the mine.

In order to reduce these impacts, companies (in the U.S.) are required to return the land to as close to its natural state as possible. Exploration companies have to remove roads and plug wells. Mining companies must fill their holes (if possible), re-grade the landscape, and replace the topsoil. When reclamation is well done, it can be difficult to determine where the mine was located. In the U.S. and much of the world, mining activities are overseen by agencies that require permits, oversee activities, and ensure proper closure when the mining is complete

GEOLOGIC RESOURCES OF ILLINOIS

Illinois has many geologic resources. The resources are typically divided into two categories; energy resources such as coal, petroleum, and natural gas and non-energy resources, which include construction, industrial, and metal resources. This section will discuss some of the more important resources of Illinois both past and present.

Early Geologic Resources

Native Americans were the first humans to use the geologic resources of Illinois. When the first European settlers arrived, they began to take advantage of the same resources

> **Chert** is a form of the mineral quartz. Chert is found in sedimentary rock and forms initially in marine environments as a chemical precipitate or from the shells of microscopic organisms. Groundwater may dissolve the quartz and redeposit it in another location, creating lenses or nodules of chert. Chert was used by Native Americans to make arrowheads and other stone tools. Chert can be found in rocks exposed throughout the state
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> **Clay** is a group of minerals formed from the chemical weathering of other minerals. Clay is found in unconsolidated sediments and sedimentary rocks and is deposited in quiet

water such as lakes and bays, on river flood plains, in some wetlands, and in the deep ocean. Clay was used by Native Americans to make pottery and is still mined and used in pottery today. Clay is also used to make bricks and cat litter and is mixed with limestone in the cement making process. Clay deposits are found throughout the state. Clay is currently mined commercially in eight counties; all of these deposits are associated with ancient oceans

Salt is also known as the mineral halite. Salt is found mixed with many of the marine sedimentary rocks of Illinois. Salt dissolves readily in groundwater, and salty groundwater emerges from springs and may be pumped from wells. If the salty water is trapped in a pool and allowed to evaporate or is placed in a kettle and boiled to drive off the water, salt is left behind. Native Americans used this resource to cure meat. Early European settlers developed the salt springs by pumping salty water into large vats and boiling it; the last of these salt works closed in 1875. Salty groundwater is found throughout the state. Some of the most extensive salt springs and wells used to collect salt were located in Gallatin and Saline counties southeastern Illinois.

Industrial Geologic Resources

Some of Illinois' geologic resources are used in industrial production of products such as steel, glass, and paint. Illinois is (or was) the top producer of these resources in the United States.

Fluorite (also known as fluorspar) (CaF_2) is the State Mineral of Illinois. The fluorite is found in fractures in limestone ($CaCO_3$) as a hydrothermal replacement deposit that formed when hot water rising toward the surface exchanged dissolved fluorine (F) for the carbonate ion (CO_3) in the limestone. Fluorite is used in the production of hydrofluoric acid, glass, welding rods, toothpaste, chlorofluorocarbons and hydrofluorocarbons (propellants and refrigerants), and steel. Fluorite was discovered in far southern Illinois (Pope and Hardin Counties) in 1818 and was mined starting in 1823. Lower priced fluorite imports caused the last mine to close in 1995; up until that time, Illinois was the top producer of fluorite in the United States.

Silica (industrial) sand is very pure quartz sand. The sand is a poorly cemented sedimentary rock that formed in a beach environment over 450 million years ago. Waves working the sand rounded the grains and removed most of the impurities. Silica sand is used to make glass, for polishing and sand blasting, to make foundry molds in which to pour molten metal, to filter water, and to hold open pore spaces and fractures near oil wells. Silica sand is also mixed into pottery clay, porcelain, plaster, and mortar. Silica sand is mined in north central Illinois in LaSalle and Lee Counties. Illinois is the top producer of silica sand in the United States.

Tripoli is a powdery rock made of microcrystalline quartz. The tripoli deposits are probably the remainder of rock that contained a mixture of limestone and chert; the rock was altered by groundwater that removed the limestone and left the silica-rich rock behind. Tripoli is used as an abrasive powder to polish glass; as a filler in paint, rubber, plastics and adhesives; and in ceramics. Tripoli is mined in Alexander County in southern Illinois. Illinois is the top producer of tripoli in the United States.

Geologic Resources used in Construction

These non-energy geologic resources of Illinois are used primarily in construction of buildings and roads.

Sand and gravel are unconsolidated sediment deposits left by running water. The water sorts the sediment, leaving the sand and gravel in lens-shaped layers. If the deposits are thick and close to the surface, they may be mined. The deposits are found adjacent to rivers, in river valleys that were filled during the Ice Age, or where rivers of meltwater flowed on and in front of the glaciers during the Ice Age. The rivers that flowed on the glaciers left sand and gravel in valleys formed of ice; when the glacier melted, the sediment remained as hills called kames and eskers. Kames and eskers are especially good for mining because it is less expensive to remove a hill than it is to dig a hole. Sand and gravel are mixed with cement to make concrete that is used for construction of roads and buildings. Sand and gravel are mined throughout the state from a variety of sources because the deposits are widely available and because it is too expensive to transport these materials long distances.

Building stone (also called dimension stone) is mined in blocks with smooth sides and, in the past as boulders. Dense, well-cemented sedimentary rocks such as limestone, dolostone, and sandstone are cut into blocks that are then used for masonry construction, paving, and roofing. In the past, boulders from glacial deposits were used as foundation stones. Building stone has been almost completely replaced by concrete, but buildings constructed of stone, including many public buildings, can still be found around the state. Building stone quarries were located throughout the state, usually relatively close to where the stone was to be used. Some of these quarries now produce crushed stone for use in concrete.

Limestone is a sedimentary rock made of the mineral calcite ($CaCO_3$). Limestone forms primarily in marine environments from deposits of fossil shells or chemical precipitates. Limestone is used primarily as crushed gravel (aggregate). When limestone is heated, carbon dioxide is given off and the remaining calcium-rich product is called lime. Lime is used as a fertilizer, as a flux in steel making, as a water softener, and as a chemical agent that removes sulfur from smokestacks. There are many other uses for lime in the chemical industry. To produce cement, limestone is crushed, mixed with clay, cooked, and the resulting product crushed to a powder. Limestone is also the primary component of most antacid tablets. Limestone is the most valuable non-energy geologic resource in Illinois and is mined throughout the state.

Metals

The metal industry of Illinois was, for a time, very important, but today all mining of metallic minerals has ceased.

Lead & Zinc are found in the minerals galena (PbS) and sphalerite (ZnS). The minerals are found in fractures in limestones and were left by groundwater. The lead and zinc are removed by heating the ore minerals until the sulfur is vaporized and the metal melts; the molten metal flows to the bottom of the smelter where it is collected and cooled. Lead is used for gun shot and in batteries. Until recently, lead was used as a pigment in paint, as a gasoline additive, and in lead pipe. Zinc is used to galvanize steel and iron; it is alloyed with copper to make brass, and rolled into sheets for roofing. Lead and zinc were mined in northwestern Illinois in Jo Daviess and Carroll Counties and in southern Illinois in Pope, Hardin, and Saline Counties. The last mine in northwestern Illinois closed in 1973 when easily accessed deposits were depleted and competition from other, less expensive, sources increased. After that, lead and zinc were mined in southern Illinois as a by-product of fluorite and mining ceased in 1995 when the last fluorite mine closed.

Iron occurs in small concretions and bands in some sediments and sedimentary rocks and was deposited by groundwater moving through the materials. Iron was mined and refined in Hardin County in southern Illinois from 1837 until 1883. The operations were small because the deposits of iron are very limited in extent and of low quality.

Energy Resources
The energy resources of Illinois are dominated by the extraction of coal, which is the most valuable geologic resource produced in Illinois.

Coal is a sedimentary rock made primarily of carbon. Coal forms in swamps when dead vegetation is buried before it can decay; over time, the dead vegetation is compacted and gradually becomes a rock. Coal quality is based on heat produced per pound and the amounts of impurities (especially sulfur) present. Illinois coal is classified as bituminous, the second highest grade of coal, and has a high heat content (13,000-15,000 BTUs/pound). Unfortunately, Illinois coal also has a high sulfur content (> 3% in many places). In the past, coal was used to heat many homes. Today, coal is burned to supply over 50% of the electricity in the United States. Coal is also used to make steel. Coal has been mined in much of the state (see map), but, due to the high sulfur content and the availability of lower priced coal from other states, demand has sagged and only a few mines remain open. In the year 2000, Illinois ranked seventh among U.S. coal-producing states.

Petroleum (oil) is found in sedimentary rocks and is the product of chemical breakdown of organic material in sediments (called the source rock). The liquid petroleum floats on water so it rises toward the surface through permeable rocks such as sandstone and some types of limestone (called a reservoir rock). If the reservoir rock is capped by a less permeable rock such as shale (called a cap rock), the oil will be blocked and will move along the boundary between the layers until it finds a way around or it is blocked by another feature such as a fold or fault (called a trap). To find oil, geologists must identify the source, reservoir, and cap rocks and find a trap. A hole is drilled into the reservoir rock below the trap and the oil is extracted. Oil is used as a fuel (it is refined to produce heating oil, diesel fuel, gasoline, and liquid propane (LP gas)), a lubricant, and in the manufacture of plastic. Oil has been found in central, southern, and western Illinois (see map). Production of oil has been declining since 1940, and Illinois is not a major oil-producing state.

Natural gas (methane) is found in sedimentary rocks and is the product of the chemical breakdown of organic material in sediments. Natural gas deposits form and are found in much the same way as oil and are sometimes found with oil. Natural gas is also found in coal seams and poses a great danger to the miners. New technology is being developed to extract natural gas from abandoned coal mines and unmined coal seams. Natural gas has been found and produced from wells in southern Illinois. Illinois is not a major natural gas-producing state.

Other Geologic Resources
Illinois has many other geologic resources. Two worthy resources of note are peat and gemstones.

Peat forms in the same way coal does, although peat is never buried deeply and is an unconsolidated deposit. Illinois peat formed primarily in mires situated in depressions left as the last glacier retreated from Illinois. Peat can be used as fuel but is used primarily as potting material in agriculture and horticulture. Peat is mined in Lake County in northeastern Illinois and in Whiteside County in northwestern Illinois. Illinois is one of the nation's top five peat-producing states.

"Gemstones" are high quality mineral and rock samples sold as decorative objects and to collectors. Until the fluorite mines closed, the primary gemstone produced in Illinois was fluorite (total sales were valued at over $250,000 in 1995). Far behind, but important to collectors are pyrite, geodes, sphalerite, galena and fossils. Collectable minerals and fossils can be found throughout the state and are mostly "mined" by amateurs. When the last fluorite mine in southern Illinois closed, the value of gemstone production in Illinois dropped to a few thousand dollars a year.

REVIEW

A geologic resource is something in the Earth that is (or could be) useful to humans and could be extracted and sold for a profit now or sometime in the future. A reserve is the identified and measured portion of a resource that can be extracted and sold for a profit now. Ore is a rock or mineral containing metallic minerals that can be mined and extracted at a profit. These definitions are all restricted by our technological ability to extract the material and by the material's value.

In order to be economic, a geologic resource must be a concentrated form of the desired material. Many geologic processes can concentrate materials that are useful to humans. Geologists can locate such concentrations by performing research based on their understanding of the processes that produce the concentrations. Geologic resources are found in igneous rocks, metamorphic rocks, unconsolidated sediment deposits, and sedimentary rocks. Originally, earth materials were mined only where they were observed exposed at the surface. The driving force behind the development of geology as a science was, in large part, a quest for valuable rocks and minerals.

In order to use a resource, it must be located, extracted, and refined for use. All three steps involve geologists. **Exploration** for geologic resources is based on a knowledge of the processes that produce those resources. **Extraction** techniques are based on the characteristics of the resource. The most common extraction methods are: strip or open-pit mining, underground mining, and pumping. **Refining** is the process or processes that prepare the resource for use. Some geologic resources may need very little refining, while others may need a lot. The amount and complexity of refining possible is based on the technology available and the value of the resource.

The use of geologic resources has many effects. The positive effects are apparent all around; the life that you lead is based on the resources that you use. Reliance on geologic resources also impacts society and the environment. None of the Earth's resources are evenly distributed, which means that people around the world must interact and trade resources. Another important aspect of geologic resources is that they are considered non-renewable. Humans extract resources faster than the natural processes replace them. Development of a resource so that it can be used can have a great impact on the Earth. The impact includes exploration, extraction, and refining. In order to reduce these impacts, companies (in the U.S.) are required to return the land to as close as possible to its natural state.

ILLINOIS STATE PARKS AND NATURAL AREAS OF NOTE FOR THEIR Mining and Mineral Resource History

Apple River Canyon (near lead-zinc mining district)
Banner Marsh (reclaimed coal mine)
Buffalo Rock (reclaimed coal mine, unreclaimed mines visible to north, silica sand mine in park)
Goose Lake Prairie (near former clay and coal mines)
Kickapoo (salt springs, near former coal mines)
Mautino (former coal mines)
Mazonia-Braidwood (former coal mines)
Pyramid (former coal mines)
Saline County (former salt wells)
Snake Den Hollow (former coal mines)
Ten Mile Creek (former coal mines)