GEOLOGIC RESOURCES OF SALT LAKE COUNTY, UTAH

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
UTAH GEOLOGICAL AND MINERAL SURVEY

UGMS PUBLIC INFORMATION SERIES 5 1990

IN COOPERATION WITH
DEPARTMENT OF COMMUNITY AND ECONOMIC DEVELOPMENT

PURPOSE

This brochure is an introduction to Salt Lake County's geologic resources and the important role they play in our economy and everyday lives. Understanding the dynamic forces that form geologic resources and the factors that influence their development and use helps us realize the value of the earth's natural assets.

The resources are divided into three categories: 1) metallic, 2) non-metallic, and 3) energy. Salt Lake County's resources are numerous, therefore only a few of particular significance to the county are discussed in detail. Their origin, mining history, extraction, and common uses are reviewed. The remaining resources and pertinent data are included in Tables 1, 2 and 3. A generalized geologic map, generalized geologic time scale, geologic resource map, and glossary (glossary words will be identified in **bold** type) are included for reading aids. Additional information can be found by contacting or visiting the Utah Geological and Mineral Survey.

CREDITS

STATE OF UTAH, Norman H. Bangerter, Governor. GEOLOGIC RESOURCES OF SALT LAKE COUNTY, UTAH is published by the UTAH GEOLOGICAL AND MINERAL SURVEY, 606 Black Hawk Way, Salt Lake City, Utah 84108-1280, (801) 581-6831. The Utah Geological and Mineral Survey, M. Lee Allison, Director, is a division of the UTAH STATE DEPARTMENT OF NATURAL RESOURCES, Dee Hansen, Executive Director. This pamphlet was published in cooperation with the DEPARTMENT OF COMMUNITY AND ECONOMIC DEVELOPMENT, David W. Adams, Executive Director.

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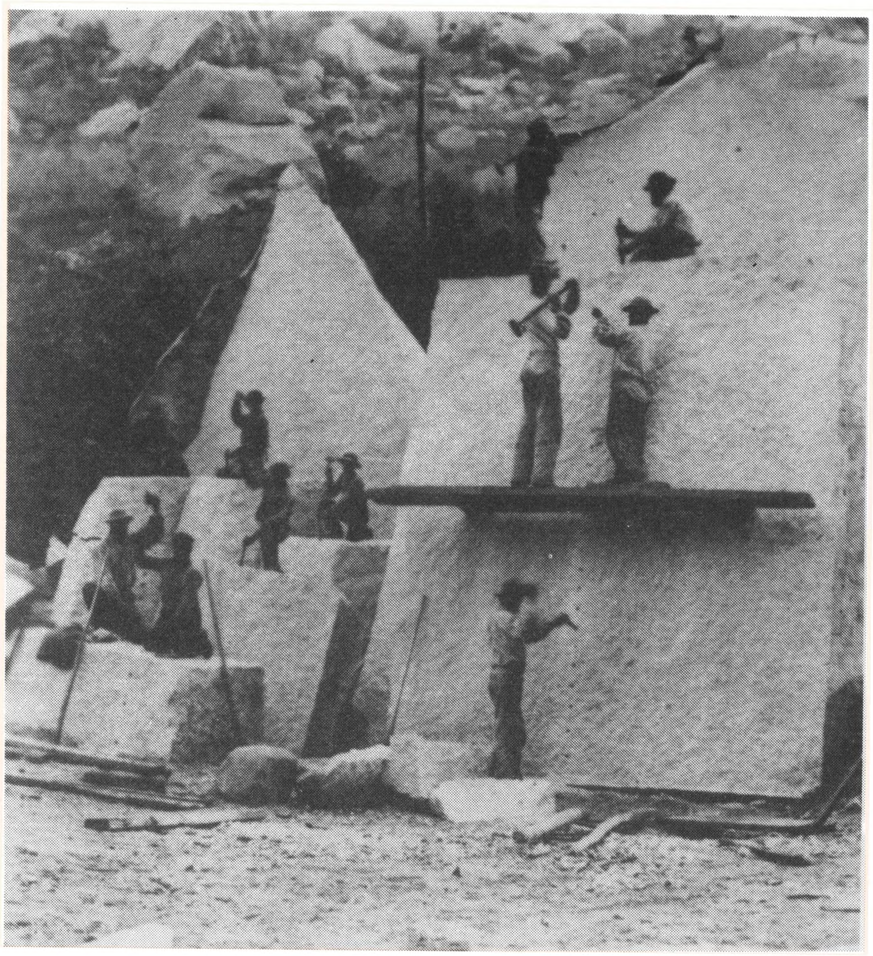
Cover photo shows sand and gravel pit operations in the foothills of the Wasatch Mountains with a view to the west across Salt Lake Valley to the Bingham Canyon Mine in the Oquirrh Mountains.

INTRODUCTION

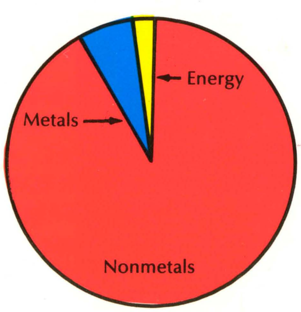
Along the shoreline of the large salty lake, families gathered salt. While men cut stone in Little Cottonwood and Red Butte Canyons, other building materials of clay (for adobe and brick), sand and gravel (for mortar) were collected in the valley. In Dry Creek Canyon and Limekiln Gulch, an additional mortar ingredient, lime, was produced by heating limestone in kilns. Men ventured into the mountains to mine lead from which they could make bullets. Stage coaches pulled in for popular stops at hot water springs along the foothills. These were typical scenes in the Salt Lake Valley area shortly after the 1847 arrival of the pioneers, illustrating several uses of **geologic resources.** Unknown to these settlers then, the valley and surrounding mountains, in what is now Salt Lake County, hosted many geologic riches. For example, the Oquirrh Mountains to the west were destined to become one of the greatest mining districts in the world.



*Quarrying **granite**-like stone (**quartz monzonite**) in Little Cottonwood Canyon, circa late 1800s. The blocks were transported to Salt Lake City for construction of several buildings, including the State Capitol Building and the Latter-Day Saints Temple. Photo credit: Utah Historical Society.*

The earth's natural resources result from complex and interacting geologic processes through time. Salt Lake County's geologic past has yielded abundant and diverse geologic resources, making the county a leading mineral producer in Utah. These resources play an important role in the county and state economies, providing a direct supply of local products needed by Utahns, and contributing to both domestic and foreign markets.

The extent to which we depend on geologic resources is remarkable. Take a look around and you will find that most of the items you use and consume are either **mineral** products, manufactured from mineral products, or grown with mineral products. For example, minerals are used in construction (limestone, sand and gravel are mixed to make concrete, and coal, iron, limestone, and molybdenum are combined to produce steel); in transportation (stone, sand, gravel, asphalt, and cement are used to build roads, while automobiles are made of aluminum, lead, copper, nickel, silver, and zinc, and oil and gas are used to run them); and in agriculture (potash is a soil fertilizer, and gypsum and limestone are soil additives).



Relative cumulative values of metals, non-metals and energy resources produced in Salt Lake County.

Buildings are made from minerals extracted from the ground and manufactured into concrete, steel, glass, bricks, nails, and other substances. The museum building in Salt Lake City's Fort Douglas *(above)* was constructed with the reddish-colored Nugget Sandstone quarried locally in Red Butte Canyon. Other natural materials used include iron brackets, nails, and bolts; silica for the windows; gypsum for the wallboard; oil derivatives for the asphalt shingles; copper and other metals in the plumbing, heating, and wiring; and coal, oil or gas for the heating.

Metallic resources comprise over 90% of the total mineral value produced in the county. The leading metals are copper, gold, molybdenum, and silver, which are primarily mined at the Bingham Canyon Mine. Non-metallic commodities are also very important to the county's economy and industrial growth. Sand, gravel, and salt are the primary non-metallics extracted. Energy resource occurrences in the county include oil, gas, uranium, and geothermal water.

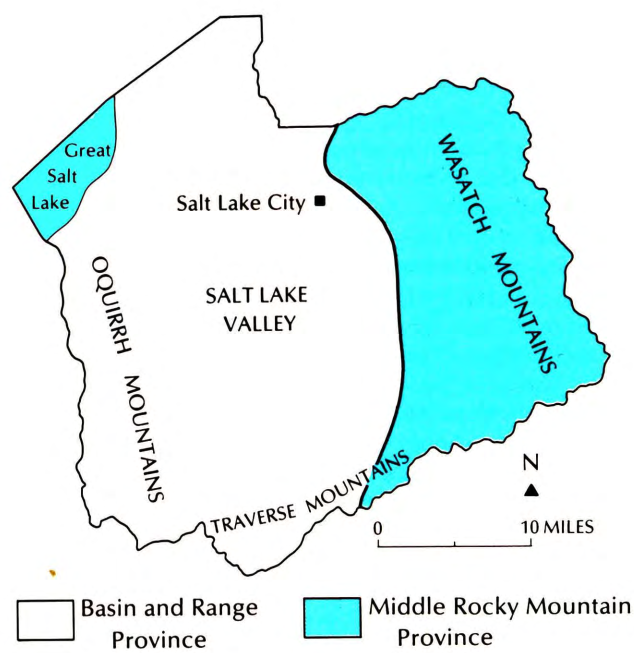
GEOLOGIC SETTING

The existence of natural resources is controlled by various geologic events that have taken place throughout time. To uncover the earth's resources, geologists and prospectors are like detectives. Their success depends on clues found in the rocks, the geologic setting, and the past geologic processes.

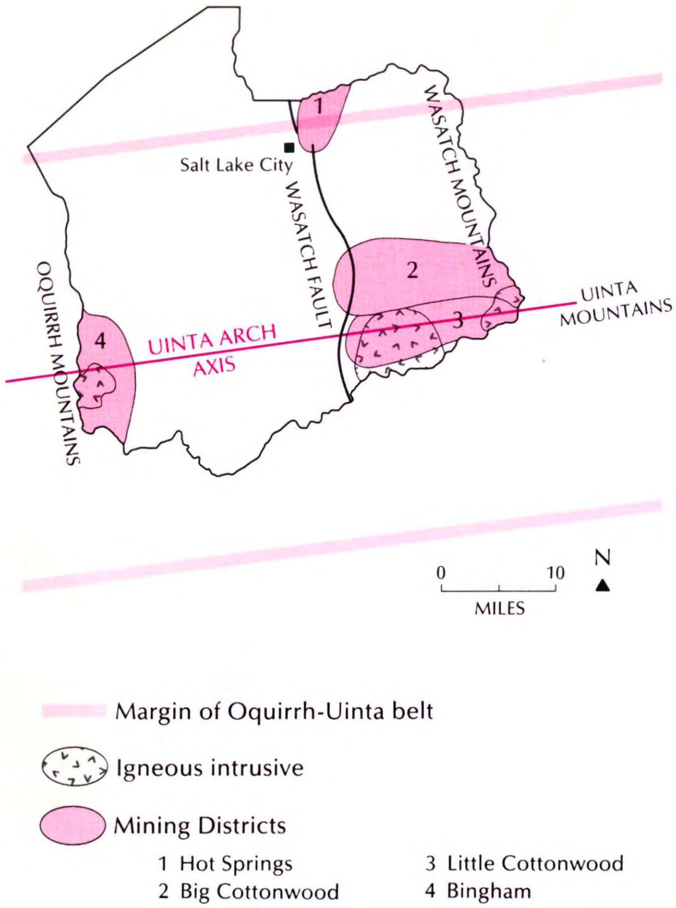
The major landforms in Salt Lake County are one main valley bounded by three mountain ranges: the Wasatch Mountains to the east, the Traverse Mountains to the south, and the Oquirrh Mountains to the west. These mountains and valley are located in two separate regions with differing landscape patterns (called **physiographic provinces**). The Wasatch Mountains are in the Middle Rocky Mountain province. The Salt Lake Valley and the Oquirrh Mountains are in the Basin and Range province, which is characterized by north-south-trending mountain ranges separated by valleys (basins). Both of these provinces are known for the mineral riches they host. The mountains contain the important metallic deposits in the county, as well as valuable non-metallic commodities such as stone. The valley contains extensive non-metallic resources, such as sand and gravel.

Two prominent geologic features of western North America, the Uinta arch and the Wasatch line, intersect in Salt Lake County. The Uinta arch is an east-west-trending uplifted area, which includes the present-day Uinta Mountains in northeastern Utah and extends west through the Wasatch and Oquirrh Mountains. The Wasatch line trends north-south through Salt Lake County and is represented by the Wasatch **fault zone** along the western base of the Wasatch Mountains. Many of the important metallic mineral deposits occur near the intersection of these two trends.

The Uinta arch was lifted up between 67 and 57 million years ago (Late Cretaceous to early Tertiary) (geologic times are shown after table 3). **Igneous rocks** were intruded along the axis of the arch from 37 to 24 million years age (middle Tertiary). This zone of igneous intrusives, called the Oquirrh-Uinta belt, contains rich **ore deposits** where it crosses the Wasatch and Oquirrh Mountains. The four mining districts in Salt Lake County are within this **mineral belt.**



The Basin and Range and the Middle Rocky Mountain physiographic provinces in Salt Lake County.

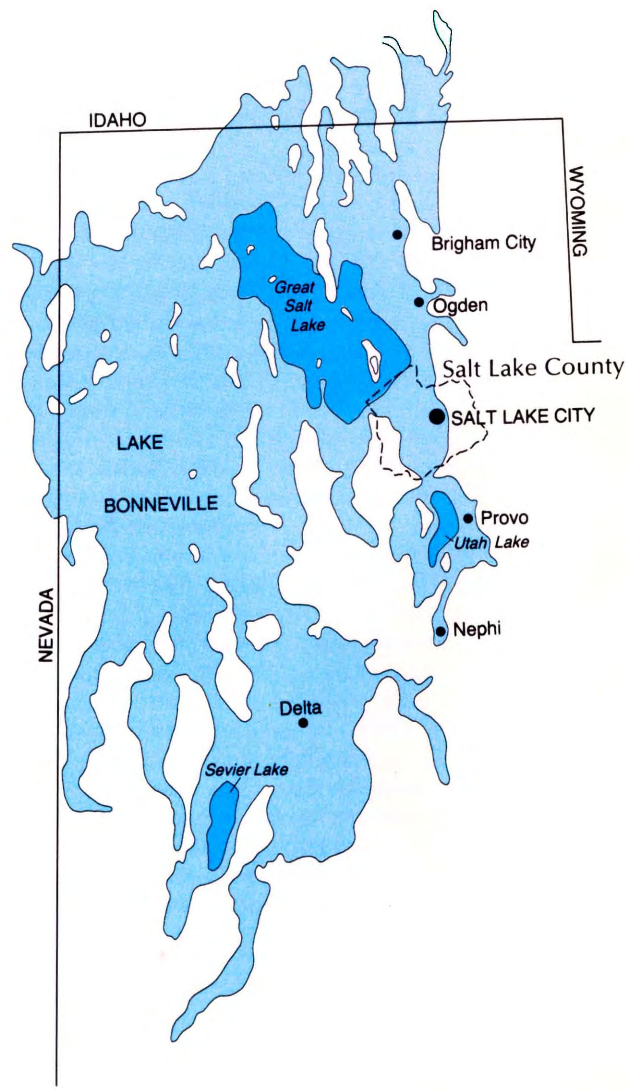


The Oquirrh-Uinta belt through Salt Lake County.

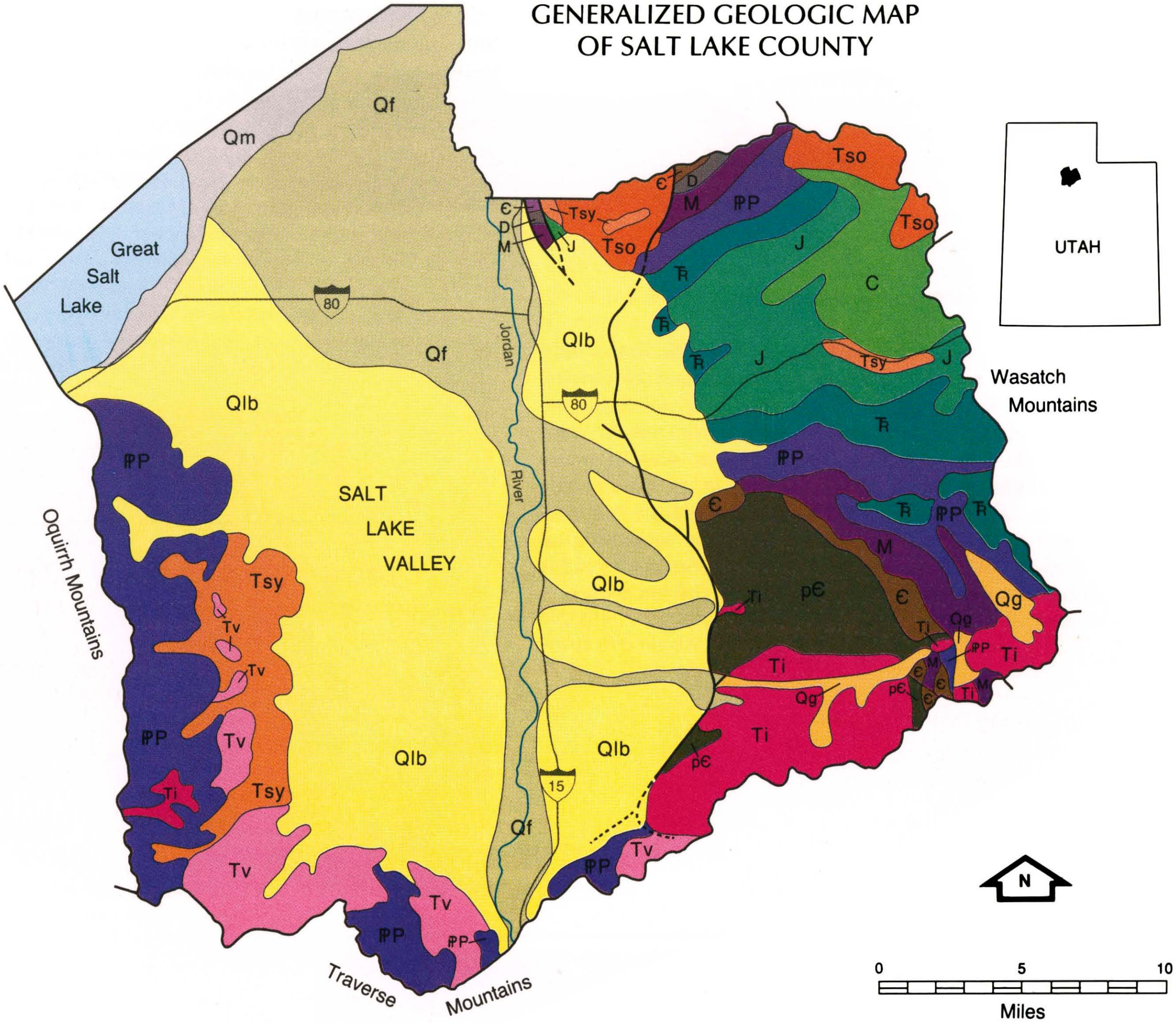
Rocks are the record of geologic time, and in Salt Lake County they reflect a nearly complete geologic story of the earth's 4.5-billion-year history. A few pages of the story are missing (known as **unconformities**) because of geologic events that either removed rocks from the area or never deposited them. Rocks are categorized into three types based on how they were formed: **sedimentary, metamorphic,** and **igneous.**

From about 1 billion to 67 million years ago (Precambrian to Cretaceous), seas intermittently flooded the area and deposited sands and muds (**sediments**), which over time were buried. Burial compacted these sediments into rocks such as sandstones, shales, and limestones (sedimentary rocks). About 67 million years ago (Late Cretaceous), the area experienced uplift, and rocks were squeezed (**folded**) and broken (**faulted**), forming mountains. Another period of mountain building followed between 67 and 57 million years ago (Late Cretaceous and early Tertiary) when, to the northeast, the Uinta Mountains rose. Some of the existing rocks were subjected to high temperatures and pressures which altered (metamorphosed) their original forms into rocks such as quartzites, marbles, gneisses, and schists (metamorphic rocks). Between 37 and 24 million years ago (middle Tertiary), volcanic centers erupted and formed rocks such as granites, rhyolites, and tuffs (igneous rocks). Yet another mountain-building event began about 15 million years ago (late Tertiary) and is responsible for the major landforms we see now. This present mountain-building episode is continuing today.

The latest chapter of Salt Lake County's geologic story is told over the last 30,000 years (Quaternary) when the valley was covered by a large ancient lake. Lake Bonneville existed 30,000 to 10,000 years ago, and covered nearly 20,000 square miles (32,200 km) in Utah, Idaho, and Nevada *(below).* It reached depths close to 1000 feet (305 m) in the area of the present Great Salt Lake. When the climate became drier, Lake Bonneville shrank in stages, etching shoreline terraces (called benches) on the surrounding mountains, like rings around a bathtub. This ancient lake left geologic resources including sand and gravel deposits in the **bars, spits, deltas,** and shorelines; and a modern lake remnant, the Great Salt Lake, provides Utah with a prominent salt industry.



GENERALIZED GEOLOGIC MAP OF SALT LAKE COUNTY

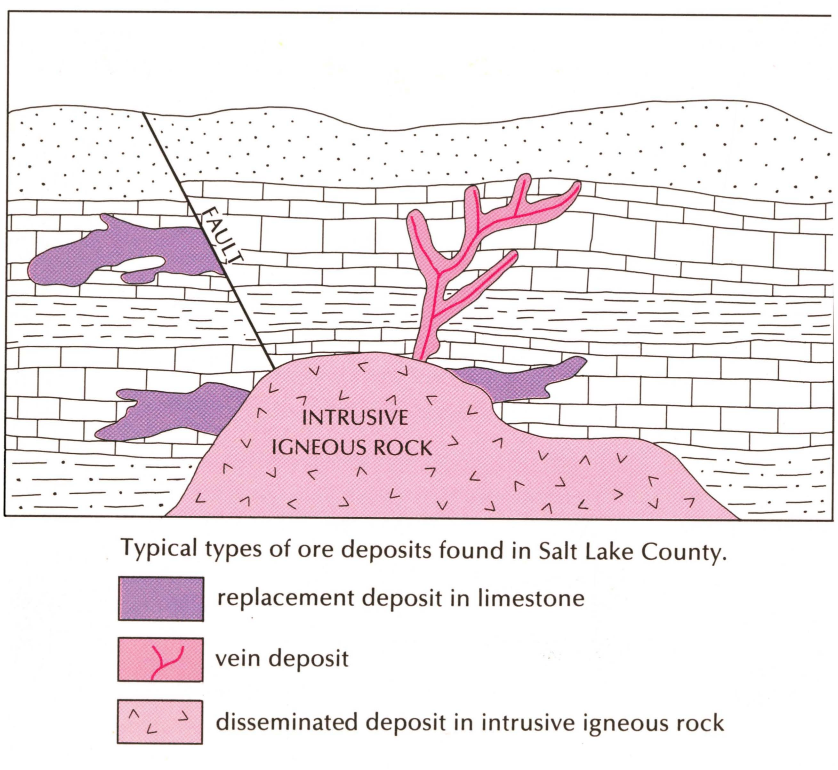


LEGEND

- Qm — Quaternary mud flats
- Qf — Quaternary flood plain deposits
- Qlb — Quaternary Lake Bonneville deposits
- Qg — Quaternary glacial deposits
- Tsy — Tertiary sedimentary rocks (younger)
- Ti — Tertiary intrusive rocks
- Tv — Tertiary volcanic rocks
- Tso — Tertiary sedimentary rocks (older)
- C — Cretaceous
- J — Jurassic
- ₮ — Triassic
- ₱P — Pennsylvanian-Permian
- M — Mississippian
- D — Devonian
- Є — Cambrian
- pЄ — Precambrian
- ——-··· Wasatch Fault Zone (dashed where approximately located; dotted where concealed.)

METALLIC RESOURCES

Metals are minerals that have a metallic luster and ordinarily are good conductors of heat and electricity. Metals occur naturally either as part of a mineral or alone. For example, lead is found both in its native state (unattached to other **elements**) or as one of many elements in over four minerals found in the county (see Table 1). Metallic minerals are usually of little use until they are mined and refined (purified) by technological processes. Galena, a lead mineral, is refined into many products, including lead-weight fishing sinkers *(right)*.



Typical types of ore deposits found in Salt Lake County.

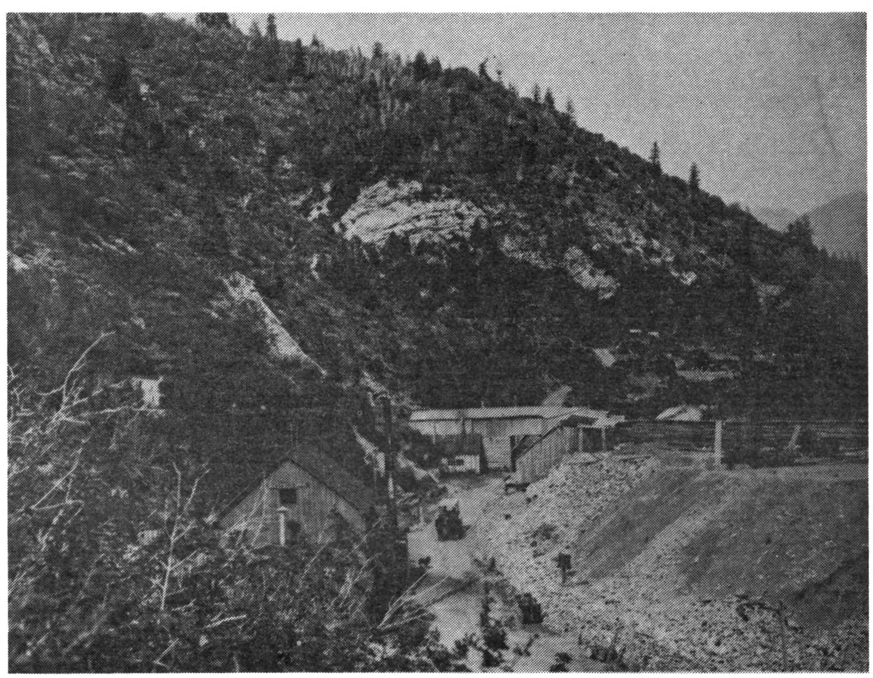
Metallic mineral deposits in Salt Lake County are commonly associated with **igneous intrusions.** These intrusions are a source of heat that provides the driving force for mineral-rich gas and liquid to move through rock openings, forming **vein** (fissure) **deposits;** or they replace the original rock minerals, forming **replacement deposits.** Veins are found in fractures of many kinds of rocks, whereas replacement deposits are typically found in specific sedimentary rocks (limestone and dolomite). Solutions can also permeate the intrusive igneous rock and deposit metallic minerals throughout the igneous rock. These are called **disseminated deposits,** of which the disseminated copper ore found in the igneous rock at Bingham Canyon is an example.

There are four **mining districts** in Salt Lake County (see Geologic Resources Map): Bingham, Big Cottonwood, Little Cottonwood, and Hot Springs. The Bingham mining district in the southern Oquirrh Mountains contains veins in various rock types, replacement deposits in limestone, and disseminated ore deposits. This district has produced over $9 billion in metal values, mostly from copper, gold, silver, and molybdenum. Approximately 2/3 of Utah's mineral production has come from the Bingham Canyon Mine. Currently, annual production is 200,000 tons of copper, 300,000 ounces of gold, 2,000,000 ounces of silver, and 12,000,000 pounds of molybdenum. Among the other commodities produced are lead, bismuth, selenium, platinum, rhenium, palladium, and sulfuric acid.

The latter three districts are in the Wasatch Mountains, and the ores occur in replacement deposits and veins in sedimentary rocks. Principally lead and silver, with minor copper, zinc, and gold were produced from the Big and Little Cottonwood mining districts amounting to over $40 million. Silver, gold, copper, and zinc were present in minor quantities in the Hot Springs district, but only a few tons of silver ore were reported shipped.

Other mining areas include the northern Oquirrh Mountains and Gold City (just north of the mouth of Little Cottonwood Canyon at the base of the Wasatch Mountains). Prospects in the northern Oquirrh Mountains have been mined along mineralized veins in Paleozoic sedimentary rocks, yielding small amounts of copper, lead, and zinc. In the Gold City area, a small amount of gold was mined in quartz veins in Precambrian metamorphic rocks.

The first documented discoveries of riches found in Utah's mountains were by soldiers. The Third California Infantry, commanded by Colonel P.E. Connor, was stationed at Fort Douglas at the base of the Wasatch Mountains overlooking Salt Lake City. Their duty was to protect the Overland Mail and Telegraph Line during the Civil War. Connor, who encouraged his soldiers to prospect in their spare time, organized a picnic outing to the Oquirrh Mountains to investigate reported mineral discoveries in Bingham Canyon. They located lead-silver ore in the upper part of the canyon; and on that day, September 17, 1863, the first mining claim in Utah was staked by the man who originally reported the mineral find (a logger by the name of George B. Ogilvie) and 25 others in the party. Connor proposed certain mining laws which were approved by the group, and the West Mountain mining district was organized. This district, which was later renamed the Bingham mining district, is famous as Utah's first and still most prominent mining district.



The Maxfield Mine in Big Cottonwood mining district yielded dividends of $800,000. Circa late 1800s. Photo credit: Utah Historical Society.

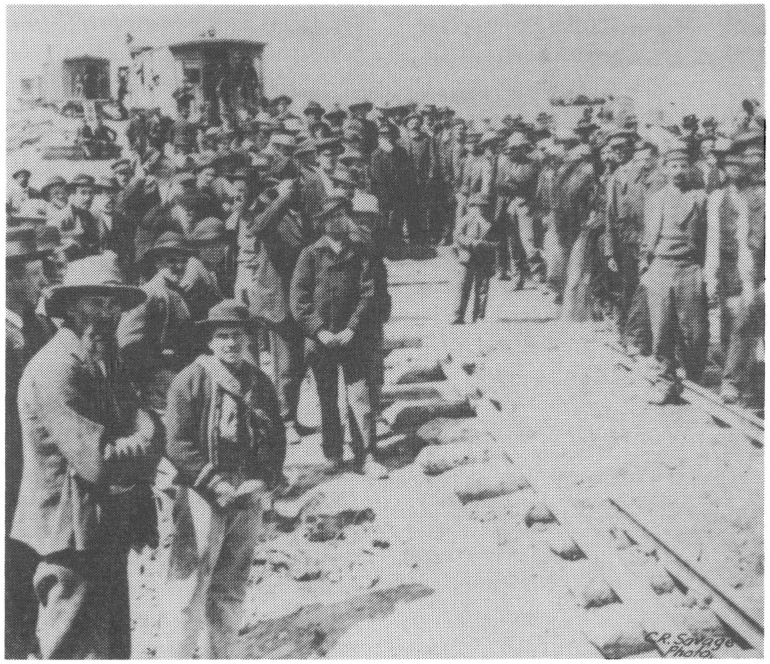
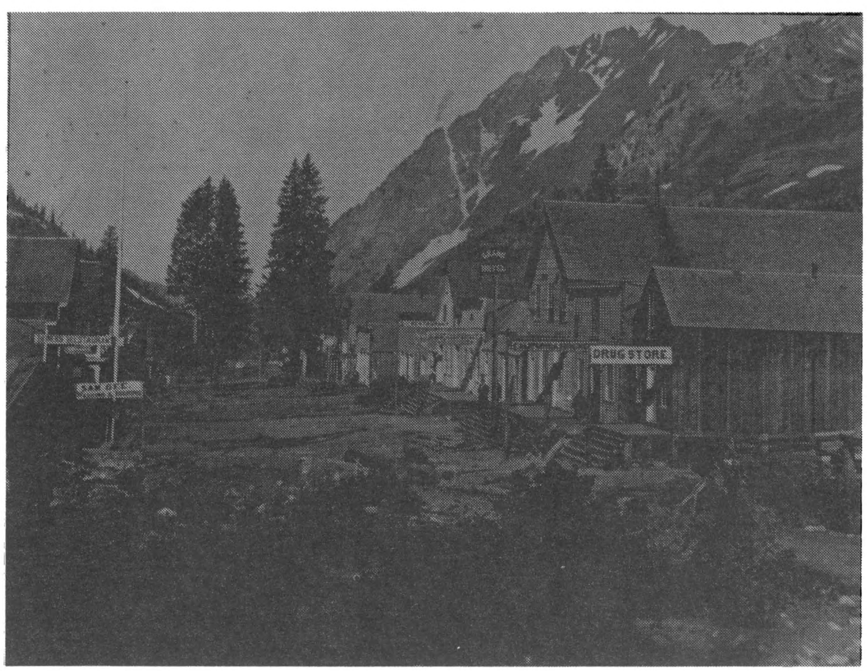


Photo credit: Utah Historical Society.

Gold **placers** (stream deposits that are mined by panning, or washing, the material in a stream bed) were discovered in the same canyon the following year. Placer gold mining was the dominant activity in the canyon until 1869 when the transcontinental railroad (the first railroad to link the east and west coasts) was completed *(above)*. The railroad system allowed transportation of large quantities of metals, and placer gold mining was replaced by lead-silver production in Bingham Canyon. In 1873, a railroad spur was built to Bingham Canyon, which further increased mining efforts there. Lead-silver production boomed from 1869 until 1893 when falling silver prices affected the district. It wasn't until the discovery of copper ores and the first commercial shipment of copper in 1896 that the district changed from solely lead-silver production to predominantly copper production.

Alta, in its heydey in the 1870s, boasted a population of over 5,000, two boarding houses, seven restaurants, two drug stores, three general stores, a blacksmith shop, a Chinese laundry, three breweries, and 26 saloons. Photo credit: Utah Historical Society.



Shortly after the Bingham discoveries, two mining districts in the Wasatch Mountains were established in Big and Little Cottonwood Canyons. Army soldiers were credited with the discoveries of silver-bearing rocks at the head of Little Cottonwood Canyon in 1864. Big Cottonwood and Little Cottonwood mining districts were organized in 1870 after a larger mining district called Mountain Lake mining district was subdivided. Each mining district covers the entire drainage of its name. The most significant mines were concentrated near the head of the canyons, and several mining camps were established. In Big Cottonwood Canyon, the mining towns of Silver Springs and Argenta flourished briefly. Argenta, located in central Big Cottonwood Canyon, became a major mining town in the canyon with 200 inhabitants by the late 1870s. In Little Cottonwood Canyon, Alta was the largest mining camp. Mining prospered in the two districts in the late 1800s and early 1900s and has continued sporadically since then.

Hot Springs mining district was located in the upper part of City Creek Canyon in the Wasatch Mountains. The mining activity in this minor district took place mostly between 1870 and 1880.

Mining and transportation were fraught with danger in the early days. Avalanches, which threatened towns, mines, and canyon transportation, took many miners' lives. Snow sheds had to be built to protect railcars travelling the canyons. Transportation of the ores from Little Cottonwood Canyon was also difficult due to the steep grades. On the downhill run, cars were let down the canyon by gravity. One brakeman could control only two cars per trip, and more than once these cars would skid and cause the panic-stricken brakemen to jump off and let the cars crash.

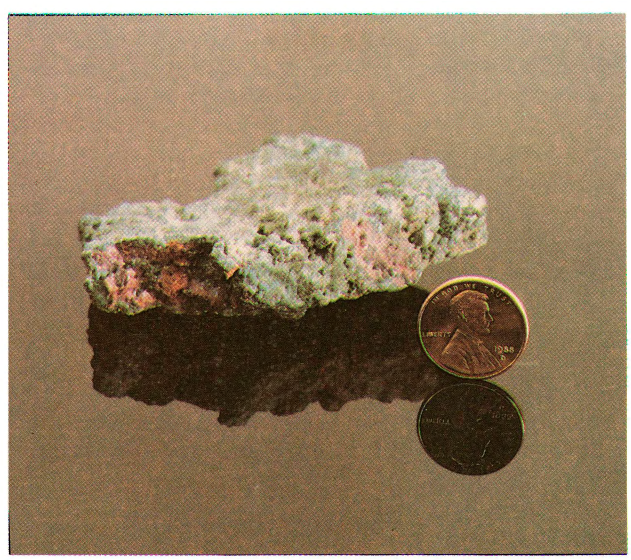
Salt Lake County's metallic resources are listed in Table 1. The leading metals produced are copper, gold, silver, and molybdenum. Further discussion is provided for copper, the most valuable commodity produced in the county and the metal that makes Utah's Bingham Canyon Mine famous world-wide; and gold, the second most valuable commodity produced in the county and one with new mining developments in the Oquirrh Mountains.

COPPER

Copper is valued for its excellent conductive properties (heat and electricity), for the ease with which it can be shaped, and for its unusual red color. Copper has been used by people for at least 6,000 years; initially it was probably utilized for tools, weapons, and ornaments. It has been an important material in the advance of industry, technology, and the arts. It is combined (alloyed) with other metals to achieve desired properties. Bronze, a name given to an entire age of civilization, is produced by adding tin to copper. Brass, used for over 2,000 years, is made by alloying copper and zinc. Since about 1840, copper has grown in importance as a necessary metal used in electricity. It is also used in building construction, industrial machinery and equipment, ornamentation, and coinage.

Copper contributes from 60 to 75% of Salt Lake County's total value of mineral output. Presently, the Bingham mining district supplies all of the county's copper. The district contains the largest known disseminated copper deposit in intrusive rock in North America and also the world's largest known replacement deposit of its type (called a skarn deposit, which is metamorphosed limestone). Due to extensive reserves in the Bingham district, copper remains Utah's most important non-fuel commodity. During some years, the Bingham Canyon Mine reports the largest annual copper production of any mine in the United States.

The Bingham Canyon Mine is unique in that it was the world's first open-pit copper mine, brought about by innovative men who visualized a profit mining the vast store of low-grade copper deposits. Because the copper is disseminated through a portion of the intrusive rock (quartz monzonite) and is of low grade (the ore contains an average of only 0.6% copper), traditional underground mining practices were not economically feasible. A proposal to mine the low-grade copper on a large scale by using steam shovels in an open pit was a revolutionary concept that was ridiculed by mining men of the era. However, due to the persistence of a man by the name of Daniel C. Jackling, open-pit mining began in 1906 and the ensuing success made history.



Copper, as it is found naturally, and after it is refined and processed into a penny.

Today, Bingham Canyon Mine *(above)* is the world's largest open-pit mine. A mountain once stood here, but removal of over five billion tons of material has created a crater which is 2½ miles (4 km) in diameter at the top and ½ mile (1 km) deep. More copper, over 12 million tons, has been removed from here than from any other mine in the world. The cumulative sale of copper from Bingham is over $6 billion. Close to 200,000 tons of refined copper are produced annually.

Not only is the copper mined at Bingham Canyon, but the concentrating, smelting, and refining facilities are all operated nearby. First, rock is blasted loose and crushed in the pit; then the rock is sent to the Copperton concentrator by conveyor belt. There, the ore is concentrated from less than 1% copper to 28% copper by separating the copper from other metallic minerals and waste rock. Next, the copper is transported through a 17-mile slurry pipeline to the smelter, located at the south end of the Great Salt Lake, where additional impurities are removed. Finally, the copper is purified in a refinery to 99.98% copper.

Copper was also produced as a byproduct from the lead and silver mining in Big Cottonwood and Little Cottonwood districts, yielding approximately 9,075 tons of copper.

GOLD

Gold was one of the first metals used by man, largely because of its workability, beauty, and primary occurrence as a native metal. It is the most malleable and ductile of all metals and one of the heaviest substances known. It has been mined in substantial amounts for at least 6,000 years. Among the earliest appearances of gold objects are in Egypt. The metal has traditionally been equated with wealth, and the lore of lost gold mines and hidden pirate treasures cannot be matched by that of any other commodity. Over the centuries gold has been a principal medium of international monetary exchange. Gold is prized for jewelry and other adornments. In the 20th century, it has also emerged as an essential industrial metal. It is used today in electronics and communication systems, in jewelry, for decoration, as a monetary value, and as a shield to protect spacecraft and similar delicate equipment from the sun's intense rays.

Gold ranks as the second most valuable commodity produced in Salt Lake County. The metal occurs in four major types of deposits in the county: replacements, veins, disseminated copper, and placers. The Bingham district itself contains each form of gold deposit.

Photo credit: Utah Historical Society.

Mining interest in Utah really sparked when gold placers were discovered in the stream gravels in Bingham Canyon in 1864. Placer deposits are the result of erosion removing the enclosing rock around the gold, and then the gold, which does not combine with other elements, is washed downslope and concentrated in the sand and gravels of the stream. The larger grains are easily recovered by washing away the lighter sand and gravel (panning), and concentrating the heavier gold. Panning for gold elicits visions of the colorful, old prospector *(left),* but there are modern-day prospectors as well, seeking gold in various Utah river beds.

Although the most successful pursuit of placer mining in the state was in Bingham Canyon, the majority of gold there has been produced underground from the Bingham Canyon Mine where the second largest known gold-rich disseminated (porphyry) system in the world exists. Approximately 15 million ounces of gold have been recovered from the mine, with annual production amounting to 300,000 ounces. Bingham Canyon Mine has been the state's principal producer of gold, and in some years ranks as one of the top five gold producers in the nation.

Big Cottonwood, Little Cottonwood, and Hot Springs districts yielded a small amount of gold from replacement deposits. Big and Little Cottonwood districts generated a combined amount of 30,647 ounces of gold. The Gold City area also produced small amounts from mineralized veins.

New gold mining operations in the Bingham mining district began in 1989 in Barney's Canyon, approximately four miles north of Bingham Canyon with two open pits, heap leaching, and processing facilities. Anticipated gold output will average 80,000 ounces per year during the projected eight years of production.

NON–METALLIC RESOURCES

The non-metallic resources are familiar sights in everyday life, since many are used essentially in the form in which they are extracted. The non-metallic materials include the rocks and minerals that are not processed for their metal content or used as mineral fuels. Gravel roads, brick fireplaces, clay ceramics, sand boxes, and stone walls are all commonplace.

Non-metallic commodities are formed by several geologic processes including igneous, sedimentary, metamorphic, and **weathering.** For example, building stones can be igneous (the quartz monzonite of the State Capitol building), sedimentary (the sandstone of the Fort Douglas buildings), or metamorphic (the marble inside the State Capitol building); and two of the ways in which clays form are by weathering of other minerals or by sedimentary processes.

Salt Lake County contains a wide variety of these resources (see Table 2). The non-metals exist in large supplies and have a long history of use. The leading non-metallic resources extracted in Salt Lake County are sand and gravel, salt, and stone. Sand, gravel, and salt are discussed for their significant industrial and economic importance.

SAND AND GRAVEL

Salt Lake County is the leading producer of sand and gravel in Utah. These materials are unconsolidated rock fragments moved and sorted by natural processes (streams, glaciers, waves on lake shores, water currents, and wind), separating fine particles of sand and silt from coarser gravel. In Salt Lake County, extensive sand and gravel deposits exist in the shore and nearshore deposits of ancient Lake Bonneville. High-quality sand and gravel deposits are found along Lake Bonneville's former shorelines, in deltas at canyon mouths, and in spits and bars

Sand and gravel pits north of Big Cottonwood Canyon. These particular deposits are in a delta that formed in Lake Bonneville.

resulting from longshore currents and prevailing winds. In Salt Lake County, over 20 active sand and gravel pits are found north of Salt Lake City and along the east bench to Point of the Mountain, as well as along the western part of the valley. Some of these resources are now inaccessible due to residential development.

These commodities were among the first to be utilized by the pioneers for making mortar to build their stone and adobe houses. Sand and gravel were also used to cover, and thus improve, the original dirt roads. After the 1869 completion of the transcontinental railroad, rapid growth ensued along the entire Wasatch Front. Many roads and buildings were constructed using large quantities of sand and gravel. Today, due to the abundant and widespread use of sand and gravel in nearly all construction projects (highways, dams, building foundations, airport runways, etc.), these commodities are of great economic and industrial importance to the Salt Lake City area. Sand and gravel are also used for traction on snow and ice, railroad ballast, fill, filtration, gardening, and playgrounds *(above)*. A few companies produce specialty sand used for sand blasting and railroad-engine traction sand.

SALT

Salt is a mineral required in the diets of all humans and other vertebrate animals. The importance of this mineral goes far back in human history. The ancient Hebrews, Greeks, and Romans used it as a religious offering; as a chief commodity, it influenced early domestic and world trade routes; and it's been used as a source of revenue by several societies. Many expressions refer to salt, such as "the man is worth his salt," demonstrating the long-lasting value of this mineral.

Salt is precipitated from natural **brines** in salt seas or lakes by evaporation of the water. In Salt Lake County, salt is extracted from the Great Salt Lake. Common salt, also known as sodium chloride or halite, is the principal salt produced from the lake. It has many uses; among them are as water softeners, in agricultural practices, for ice control on the roads and sidewalks, in soap manufacturing, and for food processing and preserving.

The Great Salt Lake is Utah's main source of salt. The area of the lake is approximately 1500 square miles (2415 sq km), making it the largest body of concentrated brine in the United States. The lake is one of the most saline lakes in the world, with an average salt content of about 25%. In comparison, the Dead Sea averages about 27% and the ocean contains about 3% salt. The lake's saltiness is due to the lack of an outlet. Rivers entering the lake carry small amounts of salt. Since there are no rivers that flow out of the Great Salt Lake, water leaves the lake mainly through evaporation. While the water evaporates, the salt remains in the lake and accumulates. Because the lake is shallow, with an average depth of 13 feet (4 m), and covers a large surface area, evaporation can occur at a high rate.

The lake's salt was used by Native American Indians and early explorers. The pioneers immediately made use of this resource when they arrived in 1847. They gathered salt from the shores by scooping it up from blanket-like deposits. When the water level rose and flooded those deposits, salt was extracted by boiling lake water in large iron pots *(right).* Eventually, production of larger quantities of salt was needed, and large man-made solar evaporation ponds were constructed *(below).*

The salt industry in Utah received its first real impetus from the discovery of silver in Montana in the mid-1860s. Salt was needed to process the silver ores and large tonnages of Utah salt were transported to Montana by trains. When the silver market dropped, salt was marketed for other uses. This demanded refining of the salt, since the brine that evaporated in the solar ponds produced very bitter-flavored salt due to the presence of other insoluble materials. In 1888, the Inland Crystal Salt Company developed a series of concentrating ponds where most of the undesirable materials would settle out in stages. In controlling the brine flow, a high-quality salt could be produced and the "bittern" discarded.

The Inland Crystal Salt Company, an early predecessor of the Morton Salt Company located in Salt Lake County, was one of the most innovative companies in the growing salt industry. The company developed a process for making salt blocks for livestock consumption, and in the 1890s, it manufactured a rock salt containing 2% sulfur which was reportedly used for treatment of blood diseases and scab in cattle. In addition, Inland Crystal was the first to use tractors *(left)* in the harvesting process. Before then,

only wheel barrows *(above)* were used because it was feared that the weight of tractors would break through the thin salt floor.

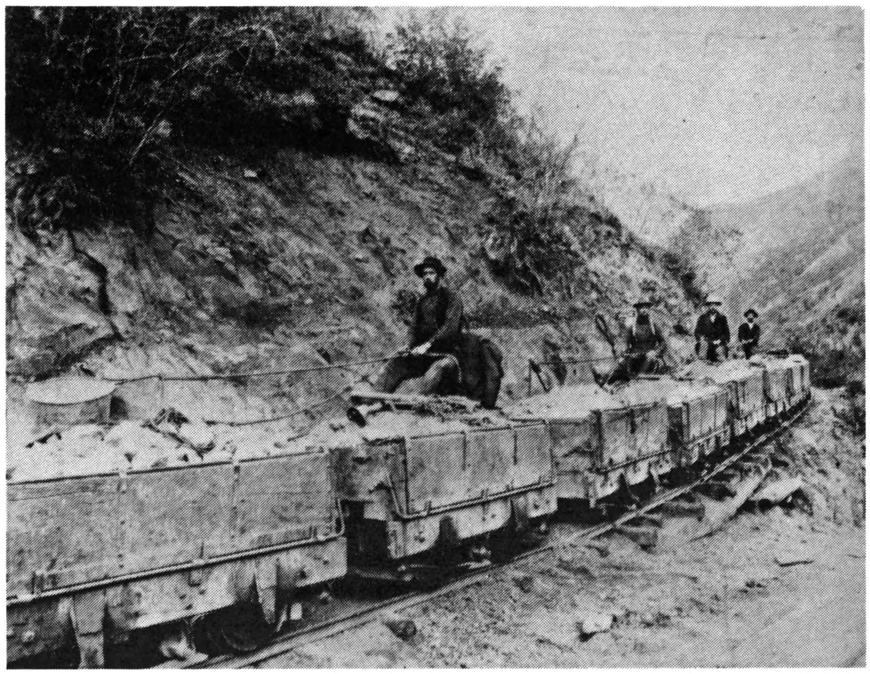
Royal Crystal Salt Company and Morton Salt Company replaced Inland Crystal Salt Company. The Saltair plant, as it is still known, was unique in that it was used by these two companies at the same time. Each company produced its own brand of salt: "Royal Crystal Salt" and "Morton Salt." In 1958, Morton Salt Company became the sole operator of the plant. Both of the labeled brands of salts are still sold by Morton, as well as other various brands of labeled salts.

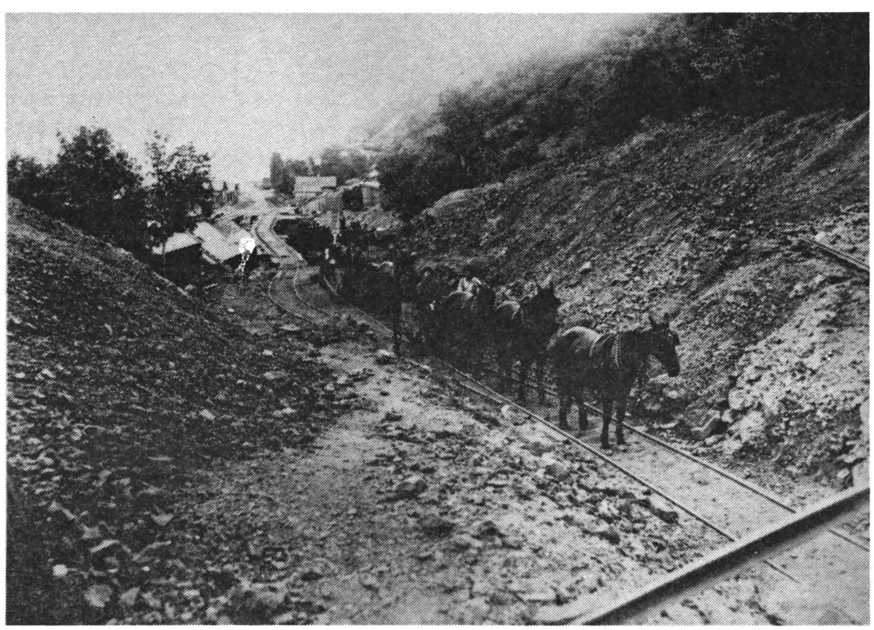
Bagging Royal Crystal Salt in the early 1900s. This salt brand has been in existence for over 100 years. It was introduced in the early 1890s and is still sold today. Photo credit: Utah Historical Society.

Aerial view of Morton Salt plant today. Photo credit: Morton International.

Morton Salt Company is the oldest salt industry on the Great Salt Lake. Today, Morton Salt Company ships between 100,000 and 200,000 tons of salt annually, making it the third largest producer of salt out of the four companies presently extracting the mineral from the lake. The biggest user of Morton's salt is the water softener industry.

ENERGY





Energy, the capacity to do work, exists in various forms. Pictured here are two older forms of energy used by people: gravity and horsepower. In the 1890s, cars transporting ore from the mines in Bingham Canyon moved down by gravity (brakemen controlled their speed), *(right)* and the empty cars were pulled back up the canyon by horses *(right)*. Later, coal provided the energy to move the trains. Today, conveyor belts have replaced the trains for transporting ore out of the Bingham Canyon Mine.

The earth and its atmosphere naturally provide energy resources that have been used for a long time, such as the sun, wind, and water. In addition, the earth's **fossil fuels** (coal, oil, and gas) played an early role in human history. These fuels were used as early as the Roman era for heating and lighting.

Energy demands increased as civilizations grew in sophistication. Competition motivated people to seek ways of performing tasks faster and better. More efficient forms of energy evolved that are used today in heating, transportation, and electric power. We experience everyday benefits from these new forms of energy: gas or electric heat in our homes instead of wood heat, transportation by fuel-powered vehicles instead of by foot or horse, and food storage in the electrical refrigerator instead of in root cellars. Our relationship to the earth and our use of its assets are dependent on energy. For example, mining, metal refining, and maintaining a clean environment all depend on energy.

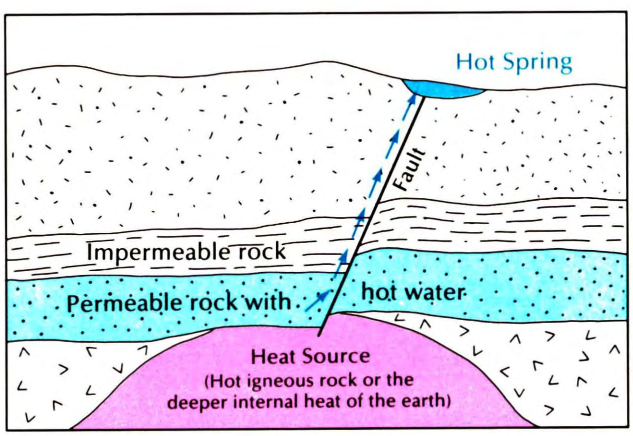
Oil and gas, uranium, and geothermal occurrences exist in Salt Lake County (see Table 3). Of the 11 oil and gas wells drilled in the county between 1927 and 1976, two had minor shows of oil and gas. The oil and gas possibilities in the county are in the Salt Lake Valley sediments and in the folded layers (strata) of Paleozoic- and Mesozoic-age rocks that may lie below the valley sediments. There is no production at present.

Uranium was extracted by processing solution from the Bingham Mine's copper tailings. This operation was active from 1977 until January 1989 when uranium prices dropped.

GEOTHERMAL

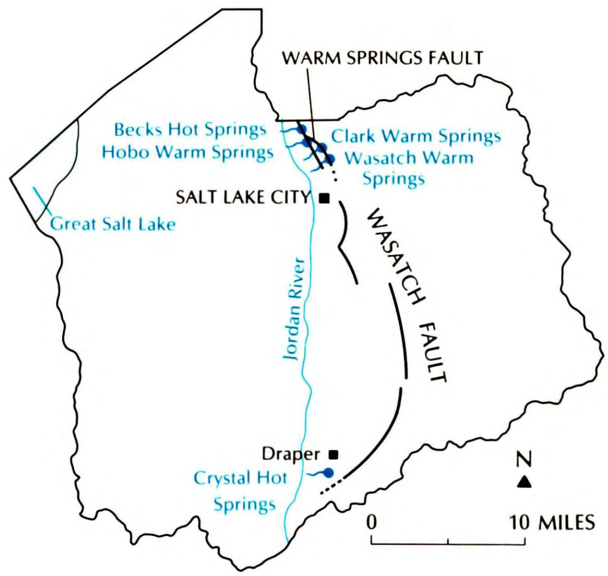
Geothermal energy is the heat contained in rock and fluid in the earth. Heat is provided either by hot igneous rock or by high temperatures found deep in the earth. Heated ground water is found in **permeable** rock layers, while the overlying **impermeable** rock layers keep the heat in. The ground water rises to the surface or near-surface along cracks (fractures or faults) in the earth. Then the heat energy is exhibited as hot springs, steam (fumaroles), geysers, or mud pots *(below).*

Hot springs have been known and used since ancient times. Because geothermal waters contain a variety of dissolved minerals, they are often considered to have medicinal value. Romans and Japanese developed hot springs for recreational and medical purposes. One of the earlier uses of geothermal energy in the United States was in Boise, Idaho. In the 1890s, two drilled wells provided hot water to residences, small commercial businesses, and an indoor swimming pool.



Today, high-temperature geothermal systems (greater than 300°F/149°C) are used to generate electricty. Uses of low- and moderate-temperature water (less than 300°F/149°C) include heating (called space heating) for homes, public buildings, farms, and greenhouses; heating of water for resorts, spas, and fish farming; and industrial process heating.

Within Salt Lake County, an area trending north-south along the Wasatch Front (see Geologic Resources Map) is considered favorable for the discovery and development of low-temperature (less than 194°F/90°C) water. This area includes the Warm Springs Fault geothermal system and the Crystal Hot Springs geothermal system *(below).* In these two areas, water is warmed by the earth's deeper heat and then flows to the surface along faults and fractures.



The Warm Springs Fault geothermal system is in northern Salt Lake County extends approximately three miles (5 km) in length and three-fourths of a mile (1 km) in width. The hot water reach the surface along the contact (probably a fault) between a Paleozoic-age limestone and Quaternary-age valley sediments. Flow rates, surface temperatures, and salinites for these springs fluctuate throughout the year. Water temperatures range from 81°F (27°C) to 133°F (56°C). Included within this system are, from north to south, Becks Hot Springs, Hobo Warm Springs, Clark Warm Springs, and Wasatch Warm Springs.

Becks Hot Springs *(below)*, at the north end of the Warm Springs Fault system, contains water ranging in temperature from 124°F to 133°F (51° to 56°C). These springs have been used for bathing and medicinal purposes. At one time, spring water flowed west into a small lake. The spring is now confined in a concrete box beneath the south-bound lane of Beck Street, and water flows west through a series of drainages and ditches into the Jordan River. Note the level terraces (they are old Lake Bonneville shorelines) above the hot springs. The embankment on the left, just above the road, was created by the Warm Springs fault. This photo pre-dates sand and gravel pits.

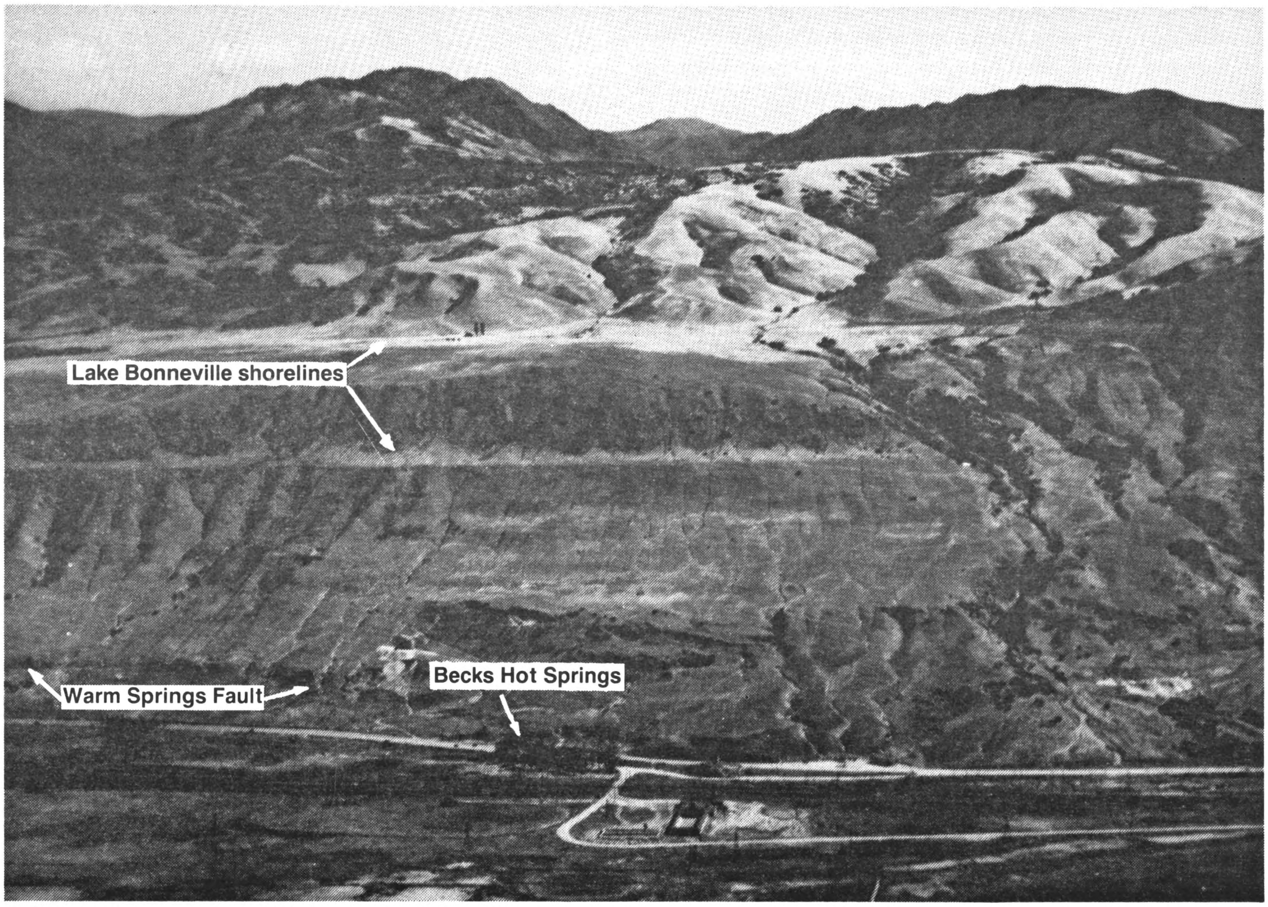


Photo credit: Utah Historical Society.

Hobo Warm Springs, three-fourths of a mile (1 km) south of Becks Hot Springs, is a remnant of a larger area of springs that existed before urbanization. Traces of the springs can be seen north of 1800 North Street, between the Union Pacific Railroad tracks and an unnamed road to the west. The maximum recorded temperature is 99°F (37°C). These waters are not used as a heat source but are combined with the flow of Becks Hot Springs and used in the sand and gravel pit operations.

Clark Warm Springs is situated between Hobo Warm Springs and Wasatch Warm Springs. The maximum measured temperature from this site is 81°F (27°C). The flow from these springs is low, and the waters are presently not used.

Wasatch Warm Springs, at the south end of the Warm Springs Fault system, is located approximately one mile (1.6 km) northwest of the Utah State Capitol Building. Temperatures range from 100°F to 108°F (38° to 42°C). In the late 1800s and early 1900s, the area was a popular bathing resort. The springs are not presently used commercially, and the water drains from the site in a number of buried pipes, eventually flowing into the Jordan River.

Four shallow wells drilled near this system supply low-temperature water (60°F/16°C) to the Church of Jesus Christ of Latter-day Saints office building in downtown Salt Lake City. This water provides space heating and cooling to the 683,000-square-foot (63,519-square meter) building.

The county's other geothermal system, Crystal Hot Springs, is 20 miles (32 km) south of Salt Lake City. Water flows from faulted and fractured Paleozoic-age rock (at depth) through overlying valley sediments into the springs. Temperatures at the springs measure between 131° and 140°F (55° and 60°C). A geothermal production well for the Utah State Prison, drilled into the Paleozoic rock, encountered higher temperatures of 185° to 194°F (55° to 90°C).

In the 1800s, Crystal Hot Springs was a stagecoach rest stop and later an inn was built at the site. In the 1920s, it was the site of a large bathing resort. Since then, in addition to swimming, the springs have been utilized to float logs for a saw mill, and to raise beavers and tropical fish. Today, wells drilled at Crystal Hot Springs provide hot water for space heating and domestic water heating at the Utah State Prison and for space heating at Utah Roses, Inc.

Heat supplied from geothermal water is used in greenhouses. Pictured here *(below)* is a greenhouse operated by Utah Roses. Inc., located next to the Utah State Prison. Water from a 400-foot-deep (122 m) well is pumped to surface water-to-water heat exchangers and then discharged. The circulating water is pumped through a system of distribution pipes and water-to-air heat exchangers to heat the greenhouse complex. Spent fluid returns in a closed loop, to the main heat exchangers where it is heated. Notice the pipes along the ground and suspended above the rose bushes. This system had been in use since 1980, and reportedly operates for about one-fourth the cost of a conventional natural gas heating system.

The remainder of Salt Lake County has been under investigation for additional low-temperature geothermal resources that are not evident at the surface and may be concealed beneath hundreds to thousands of feet of valley sediments. Potential low-temperature geothermal resource areas include (1) the north-central valley area (68° to 82°F/20° to 28°C); (2) the area immediately north of the Oquirrh Mountains (70° to 84°F/21° to 29°C); (3) the east-west portion of the central valley in the vicinity of Taylorsville, Murray, and Holladay (68° to 75°F/20° to 24°C); and (4) a north-south oriented area extending from Draper to Midvale (70° to 118°F/21° to 48°C, the temperature of 118°F was obtained after drilling to a depth of 5009 feet/1527 m).

Geothermal heat is a cleaner and, under certain conditions, a less costly source of energy than that derived from fossil fuels. For these reasons, combined with the fact that fossil fuel supplies are limited, new technological applications of geothermal energy may become important in the future.

SUMMARY

We depend on geologic resources every day of our lives. Because the formation of these resources required long periods of time and occurred under specific geologic conditions, many mineral deposits are non-renewable. Therefore, responsible development and management of geologic resources are necessary. With increased competition for various land uses (for recreational uses, wilderness areas, urban development, etc.) and growing environmental concerns, resource management requires informed decision-makers at the national, state, and local levels.

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[1]Recommended Reading lists less technical publications.

[2]Selected References lists the significant references used in this report.

Most of these publications can be purchased from the ***Publication Sales Office*** *at the* ***Utah Geological and Mineral Survey,*** *606 Black Hawk Way, Salt Lake City, Utah 84108-1280, (801) 581-6831.*

METALLIC RESOURCES

Table 1

This table lists the known metallic occurrences in Salt Lake County. Since mining activity varies depending on economic conditions, not all of the resources listed below are currently being extracted. This is not a complete list, as unexploited resources remain a challenge for future development and utilization.

Salt Lake County Metallic Resources

Commodity	Uses	Mining District or Location	Occurrence	Ore Minerals	Associated Metals
ANTIMONY	alloys batteries ceramics flame retardant glass plastics	Big Cottonwood Bingham Heughs Canyon Little Cottonwood	byproduct	pyrargyrite stibnite tetrahedrite	copper gold lead silver zinc
ARSENIC	glass making insecticides wood preservative	Bingham Little Cottonwood	byproduct	arsenopyrite enargite orpiment realgar	copper iron lead silver
BISMUTH	ceramics chemicals machine parts paints pharmaceuticals plastics	Bingham Little Cottonwood	byproduct	bismuthinite bismutite	copper gold lead silver zinc
COPPER	alloys coinage construction electrical products electronic products plumbing transportation	Big Cottonwood Bingham Little Cottonwood	replacement disseminated replace/vein replacement	azurite bornite chalcocite chalcopyrite copper covellite cuprite enargite malachite tetrahedrite	bismuth gold iron lead molybdenum silver zinc
GOLD	currency dentistry electronics jewelry ornamental	Barney's Canyon Big Cottonwood Bingham City Creek Gold City Little Cottonwood	disseminated replacement disseminated placer replace/vein replacement vein replacement	calaverite gold	bismuth copper lead molybdenum silver zinc
IRON	pig iron steel	Big Cottonwood Bingham City Creek Little Cottonwood	 disseminated replacement replacement	bornite chalcopyrite hematite limonite magnetite pyrrhotite	copper lead zinc
LEAD	batteries construction electrical products gas additive glass paint	Big Cottonwood Bingham Little Cottonwood	replace/vein dissem /replace replace/vein	cerussite galena vanadinite wulfenite	bismuth copper gold molybdenum silver zinc

MANGANESE	batteries machinery steel alloys transportation	Big Cottonwood Bingham Little Cottonwood Traverse Mountains	vein	allanite pyrolusite rhodochrosite	
MERCURY	dental pharmaceutical photography thermometers	Bingham		cinnabar mercury	lead
MOLYBDENUM	aircraft automobiles chemicals machine tools	Bingham Little Cottonwood	disseminated replace/vein	molybdenite wulfenite	copper gold lead silver zinc
PALLADIUM	chemicals dental supplies electrical products	Bingham	byproduct		copper
PLATINUM	chemicals dental supplies electrical products	Bingham	byproduct	platinum	copper
RHENIUM	aerospace craft electrical	Bingham	byproduct		copper
SCANDIUM	laser rods mercury vapor lamps	Bingham	byproduct		copper
SELENIUM	chemicals electronics glass pigments	Bingham	byproduct		copper
SILVER	alloys dentistry electrical products electronic products jewelry sterlingware	Big Cottonwood Bingham City Creek Little Cottonwood	vein/replace disseminated replacement vein vein/replace	argentite cerargyrite pyrargyrite silver tetrahedrite	copper gold lead zinc
TELLURIUM	ceramics chemicals metallurgical rubber industry	Bingham	byproduct	calaverite	copper
TUNGSTEN	aerospace industry drill bits dyes lighting television tubes	Big Cottonwood Little Cottonwood	disseminated replacement	scheelite stolzite tungstenite	lead molybdenum
ZINC	alloys brass construction electrical machinery	Big Cottonwood Bingham Little Cottonwood	vein/replace disseminated replacement vein/replace	hemimorphite smithsonite sphalerite tetrahedrite	copper gold lead silver

NON-METALLIC RESOURCES

Table 2

This table lists the known non-metallic mineral occurrences in Salt Lake County. Since mining activity varies depending on economic conditions, not all of the resources listed below are currently being extracted. This is not a complete list, as unexploited resources remain a challenge for future development and utilization.

Salt Lake County Non-metallic Resources

Commodity	Uses	Location	Occurrence
BARITE	chemicals drilling glass paints rubber	Big Cottonwood Bingham Little Cottonwood	replacement or vein
BORON*	borax products	Great Salt Lake	brine processing
BROMINE*	chemicals	Great Salt Lake	brine processing
CLAYS COMMON CLAY FIRE CLAY FULLERS EARTH	 bricks ceramics light-weight aggregate tiles refractories absorbents oil filters/bleachers	 Salt Lake benches Big Cottonwood Draper	 hydrothermal or sedimentary or weathering
GEMSTONES AZURITE GYPSUM CRYSTALS MALACHITE	 jewelry ornamental curiosity jewelry ornamental	 Bingham Great Salt Lake Bingham	 altered copper minerals evaporite altered copper minerals
LIMESTONE/DOLOMITE	cement crushed stone dimension stone lime mortar (pioneer use) refractories sugar refining	Becks Spur Emigration Canyon Ensign Peak Limekiln Gulch Parley's Canyon Traverse Mountains	sedimentary
LITHIUM*	electric batteries	Great Salt Lake	brine processing
MAGNESIUM CHLORIDE BRINE	chlorine gas dust suppressant magnesium metal	Great Salt Lake	brine processing
OOLITIC SAND	acid neutralizer smelting flux	Great Salt Lake Magna-Garfield	sedimentary
PHOSPHATE ROCK	animal feed supplement chemicals fertilizer	Dry Creek Canyon Millcreek Canyon	sedimentary
POTASH	fertilizer	Great Salt Lake	evaporite
SALT	animal feed supplement chemical industry ice control food water softeners	Great Salt Lake	evaporite

SAND AND GRAVEL	aggregate for concrete construction fill filtration mortar (pioneer use) winter road safety	Lake Bonneville Wasatch Front	sedimentary
SILICA	abrasives electronics glass refractories	Mount Olympus North Salt Lake Point of the Mountain	metamorphic (quartzite)
SODIUM SULFATE	ceramics detergent filler paper	Great Salt Lake	evaporite
STONE	aggregate, construction dimension stone dimension stone cement, dimension stone dimension stone	Becks Spur Emigration Canyon Little Cottonwood Parley's Canyon Red Butte Canyon	igneous or sedimentary
SULFUR	sulfuric acid	Bingham smelter	smelter byproduct

**Potential commodities from the Great Salt Lake.*

ENERGY RESOURCES

Table 3

This table lists the known energy resource occurrences in Salt Lake County. Since mining and drilling activity varies depending on economic conditions, not all of the resources listed below are currently being extracted. This is not a complete list, as unexploited resources remain a challenge for future development and utilization.

Salt Lake County Energy Resources

Commodity	Uses	Location	Occurrence
GAS AND OIL	asphalt fuels plastics solvents waxes	Salt Lake Valley	Quaternary and Tertiary sediments Mesozoic and Paleozoic strata
GEOTHERMAL	electricity space heating water heating	Wasatch Front	faults earth's internal heat igneous bodies
URANIUM	nuclear fuels nuclear weapons radiosotopes (medical) x-ray targets	Bingham Canyon Mine	veins in shales

GENERALIZED GEOLOGIC TIME SCALE WITH GEOLOGIC RESOURCES

Era	Millions of years ago	Period	Main types of rock or deposit	Economic value
Cenozoic		Quaternary	Great Salt Lake Lake Bonneville shorelines, spits, bars, and deltas Lake Bonneville sediments Jordan River floodplain	salts sand and gravel, clay gas, clay clay
	1.6	Tertiary	extrusives - andesite and latite intrusives - quartz monzonite sedimentary - conglomerate, siltstone, sandstone	ore host ore host dimension stone
Mesozoic	66.4	Cretaceous	conglomerate, siltstone sandstone, limestone	
	144	Jurassic	sandstone limestone sandstone	cement dimension stone
	208	Triassic	shale, limestone	
Paleozoic	245	Permian	limestone limestone quartzite sandstone, siltstone, quartzite	lime contains phosphatic shale ore host ore host ore host
	286	Pennsylvanian	quartzite limestone quartzite, limestone limestone	ore host ore host lime
	320	Mississippian	limestone limestone limestone limestone dolomite	ore host, lime ore host, lime crushed for aggregate crushed for aggregate, ore host crushed for aggregate, ore host
	360	Devonian	limestone quartzite, sandstone	crushed for aggregate crushed for aggregate
	408	Silurian		
	438	Ordovician		
	505	Cambrian	limestone sandstone, limestone shale quartzite	crushed for aggregate, ore host crushed for aggregate, ore host potential source of silica
	570	Precambrian	quartzite, shale tillite quartzite, argillite, shale schist gneiss, schist	potential source of silica potential source of silica, ore host, clay products ore host source of feldspars for potential ceramic resources

GLOSSARY

bar — submerged to emerged ridge or mound of sand and gravel deposited by waves and currents near the shores of an ocean or lake.

brine — water containing abundant salt.

delta — a deposit of sediment formed at the mouth of a river where it enters an ocean or lake.

deposition — the dropping of sediment from water, air, or ice.

disseminated deposit — a type of mineral deposit in which the minerals occur as small particles scattered through the rock.

element — a substance that cannot be broken down into a simpler substance.

erosion — a group of processes whereby earth or rock material is loosened or dissolved and moved from one place to another.

fault — a break in rocks, along which one side has moved relative to the other side.

fault zone — an area consisting of numerous faults.

fold — a bend in the rock layers.

fossil fuels — fuels (coal, oil, and gas) formed from plants, algae, plankton, etc. (organic fossil materials) that were buried, compressed, and subjected to heat and chemical changes.

geologic resource — a natural product of the earth on which people depend for shelter, transportation, food, etc.

granite — a very common pink or gray intrusive igneous rock having individual mineral grains large enough to be seen easily without a magnifier. The minerals are mostly quartz, feldspar, hornblende, and mica.

igneous rocks — rocks formed by cooling and hardening of hot liquid material (magma), including rocks cooled within the earth (**intrusive,** such as granite and quartz monzonite) and those poured out onto the surface as lavas (**extrusive,** such as basalt and rhyolite).

impermeable rock — rock, made of tightly packed mineral grains, which does not allow much water to pass through (such as shale).

intrusion — a body of igneous rock that hardened before it reached the earth's surface.

metamorphic rocks — rocks formed by high temperatures and pressures encountered when existing rock is reburied within the earth (such as gneiss, usually formed from granite; quartzite, formed from sandstone; and marble, formed from limestone).

mineral — an inorganic element or compound occurring naturally in the earth's crust. In a broad nontechnical sense, the term embraces all inorganic and organic substances that are extracted from the earth for use by people. (Organic substances — which include oil, gas, and coal — were once part of, or made by, living plants and animals).

mineral belt — a tract of land that contains many mineral deposits and mining districts relative to other areas.

mining district — an area with described or understood geographic boundaries within which mineral deposits are found and mined under rules and regulations prescribed by the miners therein.

ore deposit — a mineral, or aggregate of minerals, which has economic value.

permeable rock — rock, made of relatively loosely packed mineral grains, which allows water to pass through (such as sandstone).

physiographic province — a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

placer deposit — a deposit of heavy minerals (gold, for example) concentrated in stream gravel.

quartz monzonite — an intrusive igneous rock that is very similar to granite, but contains a different ratio of feldspar and quartz minerals.

replacement deposit — a type of mineral deposit formed from solutions that dissolve existing rock and deposit ore minerals in its place.

rock — a naturally formed solid material that is usually made of minerals.

sedimentary rocks — rocks formed from loose sediment such as sand, mud, or gravel deposited by water, ice, or wind, and then hardened into rock (such as limestone, sandstone, and shale); or formed by dissolved minerals dropping out of solution to form rock (salt, for example).

sediments — small bits of rock fragments and sometimes organic matter deposited by water, ice, or wind.

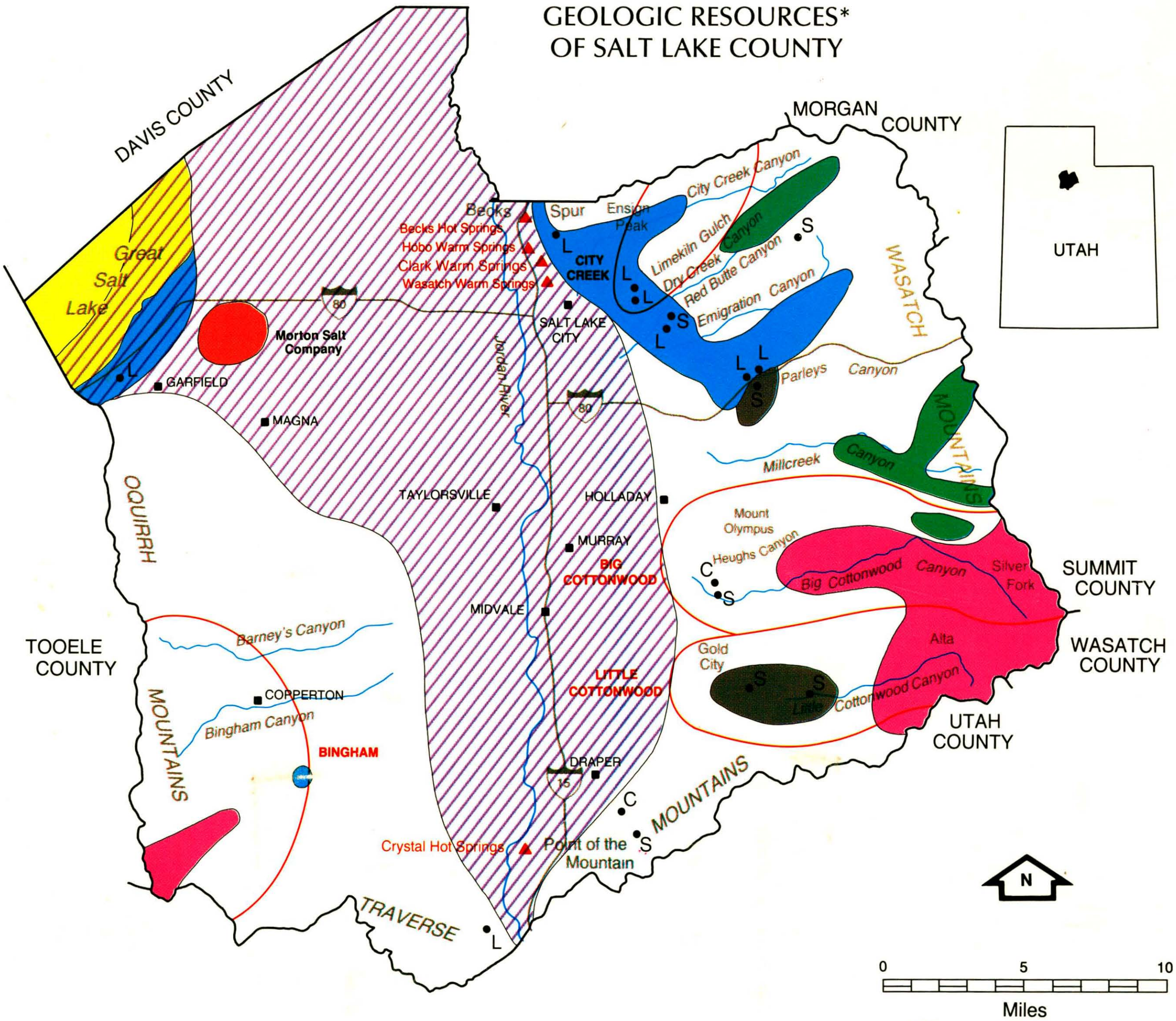
spit — a small point of land projecting into a body of water from the shore.

unconformity — surface of erosion or nondeposition separating sequences of layered rocks, producing a break or gap of time in the sequence of rock layers.

vein deposit — a type of mineral deposit that fills a fracture in rock or replaces the rock on the sides of a fracture.

weathering — the breaking down of rocks into smaller pieces by natural processes.

GEOLOGIC RESOURCES* OF SALT LAKE COUNTY



LEGEND

- Mining District
- ▲ Hot Spring
- Solar Pond

Black dots indicate occurrences; colored areas indicate favorability for discovery and development.

- Geothermal low temperature water less than 194°F (90°C)
- •B Barite
- •C Clays
- •P Phosphate
- •L Limestone & dolomite, calcite, oolitic sand
- •S Stone, silica
- Salines (brines, salt, potash & others)

**Not all resources are mapped; see Tables 1, 2, and 3 for a complete list. Refer to the Generalized Geologic Map to locate sand and gravel deposits, which are generally found in the Quaternary Lake Bonneville deposits.*