GEOLOGIC RESOURCES OF BOX ELDER COUNTY, UTAH

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

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in cooperation with
DEPARTMENT OF COMMUNITY AND ECONOMIC DEVELOPMENT

PURPOSE

This brochure is a basic introduction to Box Elder County's geologic resources and the role they play in our economy and everyday lives. To recognize their existence and realize their importance, it is essential to understand the dynamic forces that form geologic resources and the factors that influence development and uses of these assets.

The county's resources are many, therefore, detailed treatment of each cannot be provided here. Discussion of few selected commodities highlights the origin, mining history, extraction, and common uses of the non-metallic, metallic, and energy resources found in the county. The remaining resources and pertinent data are listed in tables 1, 2, and 3.

CREDITS

STATE OF UTAH .... Norman H. Bangerter, Governor.
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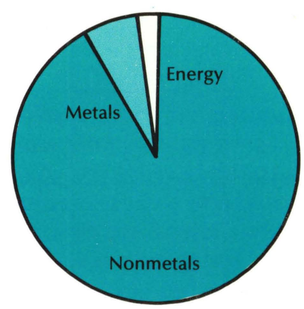
INTRODUCTION

Box Elder County has abundant and diverse geological resources. These natural assets are valuable because they constitute an important part of the county's as well as the state's economy. They provide a direct supply of local products needed by Utahns, and contribute to both domestic and foreign markets. Although the mineral market fluctuates depending on economic conditions, an ever-increasing mineral output is needed to satisfy the demands of population growth.

Appreciation of geologic resources and their importance is gained when we look around us and see how much of what we use in everyday life comes from the earth. Historically, these resources have always been important to man. In this country, Native American Indians used stone and clay for implements; gemstones for ornaments; and minerals of various colors for pigments. Today, our use of natural resources has greatly expanded, and will continue to do so, in response to increasing demands brought about by larger populations and industrial growth. The list of resources used for products familiar in everyday life is extensive. Salt is used in food and for ice control on the roads and sidewalks; gold and silver fillings are used in dentistry; phosphate and potash are used in fertilizers and soaps; copper is employed in electrical wiring; silica-rich sand is transformed into window glass; copper, iron, lead, molybdenum, and other metals are used to manufacture automobiles, telephones, and refrigerators; and coal, gas, and oil are used to heat our homes and generate electricity.

The county's mineral resources are divided into three categories: 1) non-metallic resources, 2) metallic, and 3) energy.



Relative cumulative values of nonmetals, metals, and energy in Box Elder County.

Houses are made of many geologic resources. This home features various types of stone used for the ornamental facade, the chimney, and the walls around the home and driveway; concrete walkway, steps, and driveway (made from limestone, clay, crushed rock, and sand); windows (of which silica is a component); aluminum garage door; asphalt (petroleum product) shingles; and red paint (minerals are used to color and process paints). Other resources used are lead in the original windows; gypsum for the wallboard in walls and ceilings; stone for a decorative fireplace; metals for the plumbing, heating, and wiring; and coal, oil, or gas for the heating.

GENERALIZED GEOLOGIC TIME SCALE WITH GEOLOGIC RESOURCES

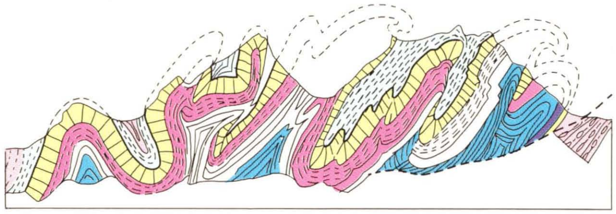
Era	Millions of years ago	Period	Main types of rock or deposit	Economic value
Cenozoic		Quaternary	Great Salt Lake alluvium eolian dunes Lake Bonneville deposits Lake Bonneville sediments	salts gravel sand, oolite, gypsite sand, gravel, sodium and potash brines, diatomite gas
	1.6	Tertiary	*volcanic* - basalt rhyolite, tuff *sedimentary* - sandstone, conglomerate, siltstone, shale	oil fill material, soil conditioners, clay, ornamental stone, gemstones, lignite lignite
Mesozoic	66.4	Cretaceous		
	144	Jurassic		
	208	Triassic	limestone, shale, sandstone	
Paleozoic	245	Permian	limestone chert mudstone dolomite sandstone	riprap host for variscite contains phosphatic shale riprap, railroad ballast, crushed stone
	296	Pennsylvanian	limestone, shale, sandstone	riprap, railroad ballast, crushed stone, host for variscite and tungsten
	320	Mississippian	siltstone limestone sandstone limestone	riprap, railroad ballast, crushed stone, lime, soil conditioning, sugar refining riprap, crushed stone
	360	Devonian	shale limestone dolomite	ore host, riprap, railroad ballast, crushed stone riprap, crushed stone, refractories
	408	Silurian	dolomite	ore host, riprap, crushed stone
	438	Ordovician	dolomite quartzite dolomite quartzite, sandstone siltstone, argillite limestone	ore host, riprap, crushed stone possible source of high silica sands possible source of high silica sands riprap, crushed stone, host for tungsten
	505	Cambrian	marble dolomite, limestone quartzite	dimension stone, crushed ornamental stone ore host, riprap, crushed stone dimension and ornamental stone, mica, riprap
Precambrian	570		quartzite gneiss schist	dimension stone, riprap ore host, pegmatite minerals ore host

GEOLOGIC SETTING

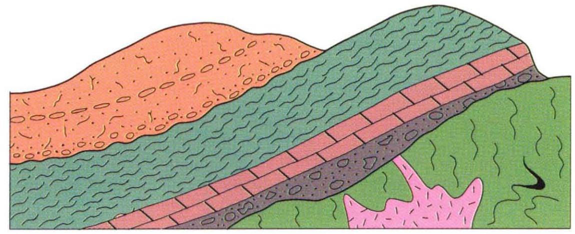
The existence of natural resources results from various geologic events that have been taking place throughout geologic history. Box Elder County contains 5594 square miles of land and 800 square miles of water (the Great Salt Lake), making it the fourth largest county in the state. Located in the northwest corner of Utah, it is within the Basin and Range physiographic province. The oldest rocks in the county are of Precambrian age.

These ancient rocks were metamorphosed, or altered, from their original form by high temperatures and pressures, and turned into schists and quartzites. The next oldest rocks represent the Paleozoic era. At intervals from the Cambrian through the Triassic, shallow seas flooded the county and deposited sands and muds which became sedimentary rocks including sandstones, limestones, dolomites, and shales. After the Triassic, the area expe-

The Basin and Range province is characterized by north-south trending, narrow, isolated, nearly parallel mountain ranges separated by basins (valleys). The view here is from one range looking across a valley to the next range with snow-capped peaks.



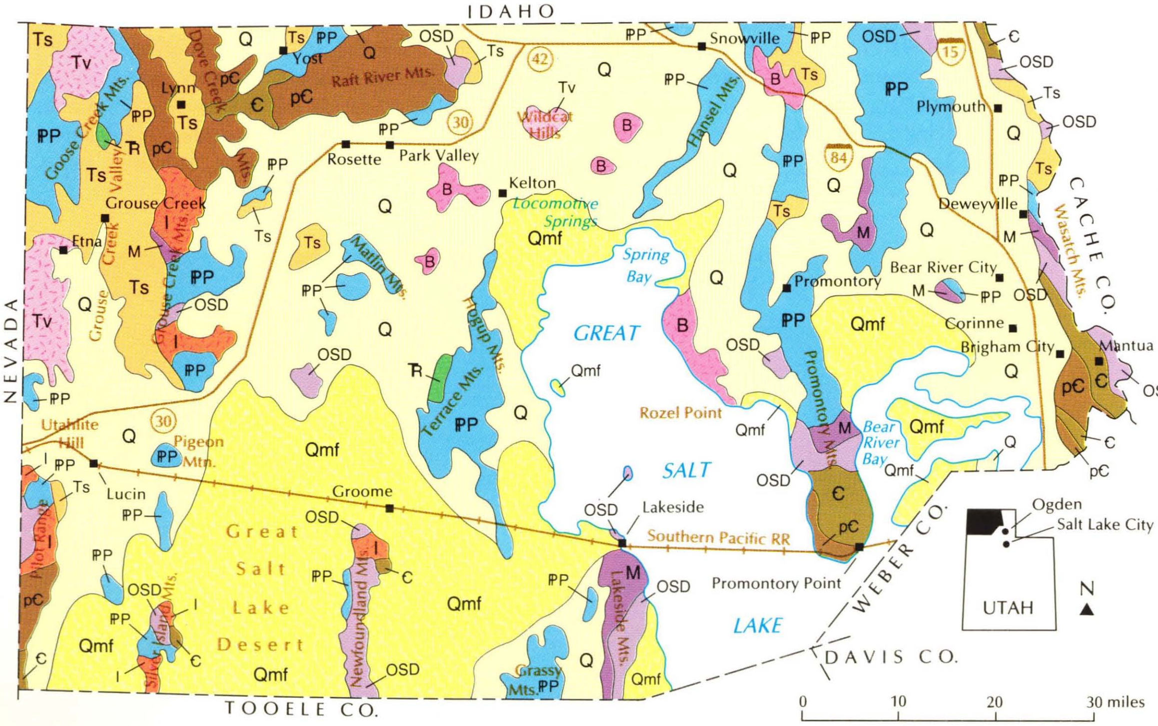
Mountains formed by folding

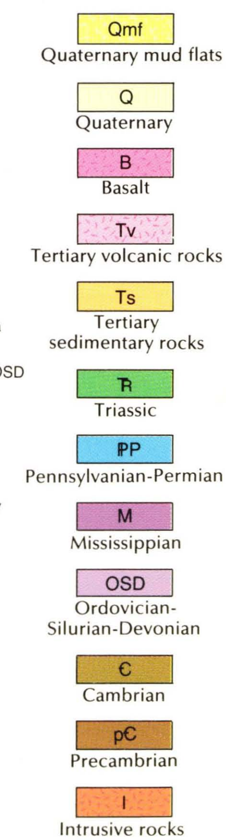


Mountains formed by tilting

rienced erosion and mountain building. The existing rocks were subjected to multiple episodes of folding (squeezing) and faulting (breaking).

Volcanic centers erupted during the Tertiary (Cenozoic era) and formed different kinds of rocks, such as granite, basalt, rhyolite, and tuff. Heat from this igneous activity altered the chemistry (mineral content) of the surrounding rocks and often formed metallic mineral deposits. Regional heating of the area is also noted by the presence of hot springs.

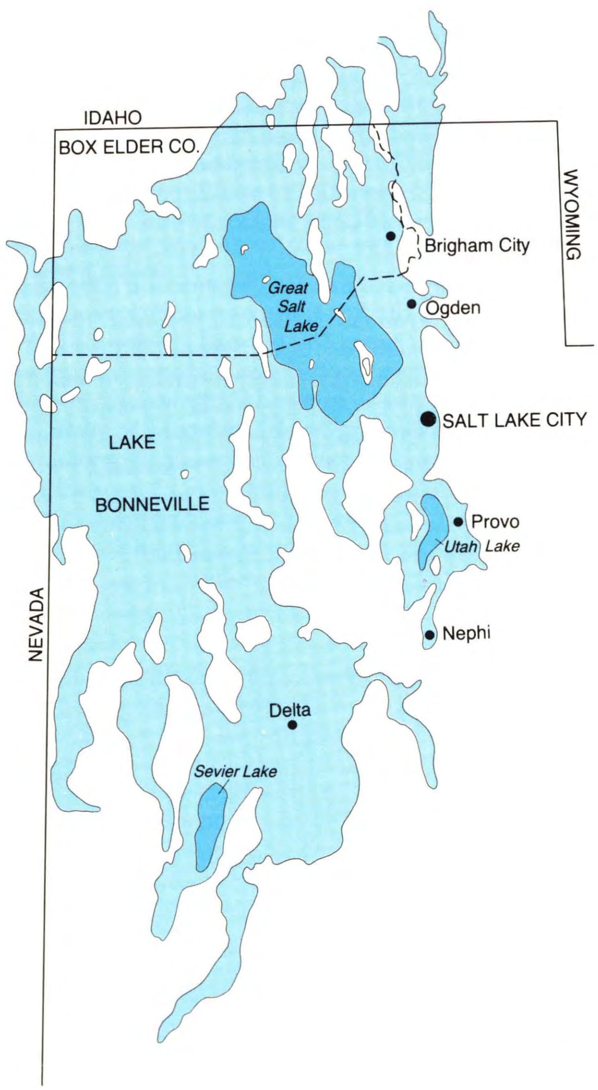




GENERALIZED GEOLOGIC MAP OF BOX ELDER COUNTY, UTAH

During the late Tertiary, the area began to break into large blocks which were eventually tilted up to form today's mountain ranges. Sediments, deposited by rivers and lakes, accumulated in the valleys that formed between the mountain ranges. This deposition continued into the Quaternary period. The Quaternary deposits cover a large portion of the county and were mostly left by a large lake that existed 30,000 to 10,000 years ago. This lake, named Lake Bonneville, covered a vast area of Utah, including all but the northwestern-most corner of Box Elder County. Many of today's non-metallic resources were left by Lake Bonneville.

All of these complex and interacting geologic processes combined to make Box Elder County rich in the various types of geologic resources. All known geologic resources in the county are listed in tables 1, 2, and 3. Although each commodity has unique qualities, only a few from each category are discussed in detail. They are chosen for their particular significance to Box Elder County.



Lake Bonneville covered nearly 20,000 square miles in Utah, Idaho, and Nevada. It was almost 1000 feet deep in the area of the present Great Salt Lake. Lake Bonneville decreased in stages as the climate became drier. This ancient lake supplied us with geologic resources such as sand and gravel deposits in the bars, spits, deltas, and lake terraces; diatomite and gypsum deposits; and a modern lake remnant, the Great Salt Lake, which provides Utah with a prominent salt industry.

NON-METALLIC RESOURCES

The non-metallic resources are familiar sights in everyday life. Sand boxes, gravel roads, brick fireplaces, clay ceramics, and stone walls are all commonplace. The non-metallic materials include the rocks and minerals that are not processed for their metal content or used as mineral fuels. Non-metallic commodities are formed by several geologic processes including igneous, sedimentary, metamorphic, weathering, and ground-water movement.

Box Elder County contains a wide variety of these resources (see table 1). The non-metals have yielded the largest cumulative value of all the commodities in the county (over 90%) due to large supplies and a long history of continuous exploitation. Stone from the mountains, salt from the Great Salt Lake, and sand and gravel left by Lake Bonneville all represent ample resource supplies. Natives and early explorers made use of the available deposits. When the pioneers, arrived in 1847, they gathered salt for dietary needs from the Great Salt Lake, and for their buildings they quarried stone, fired clay for adobe and brick, and used sand and gravel to make the mortar.

The construction industry has been the largest consumer of non-metallic resources in the county. Construction materials, principally stone and sand and gravel, have provided roughly 75% of the cumulative mineral value produced in Box Elder County . Railroad bed construction has been the major user of crushed and broken stone, while road construction has been the main user of sand and gravel.

The earliest large-scale use of construction materials in the region was for the first transcontinental railroad built across the United States. The railroad crossed Box Elder County from Brigham City through Corinne, Promontory, and Kelton, across the Hogup and Matlin Mountains to the south end of the Grouse Creek Mountains to Lucin, and then along its present route into Nevada. Completed at Promontory in 1869, the original railroad bed, which is now used as a road or stock trail, was constructed out of local gravel, borrow (earth material, such as dirt, sand, and gravel, used as fill), and crushed stone.

Road construction industry is a major user of crushed stone, sand, and gravel.

Over 43 million cubic yards of crushed stone, sand, and gravel were used to build this railraid causeway across the Great Salt Lake. An abandoned wooden trestle can be seen continuing in a straight line west towards Lakeside, while the rock-filled causeway branches off to the right. When the original railroad bed built in the early 1900s sank to unexpected depths in the lake bottom sediments, a 12-mile long wooden trestle was built east of Lakeside in its place. This trestle eventually deteriorated and was judged unsafe, so the solid, rock-filled embankment shown here was built from 1955 to 1959. During this time, Box Elder County was the state's leading producer of stone and sand and gravel.

The next major construction occurred in 1902 and 1903. A new railroad route, called the Lucin Cutoff, was established to shorten the original track distance from Ogden to Lucin by almost 44 miles. A 20.6-mile long causeway was constructed across the Great Salt Lake from Promontory Point to Lakeside. From Lakeside the railroad bed was built across 50 miles of mudflats. The tonnage of crushed rock, gravel, sand, and borrow used for causeway fill across the lake and railroad ballast across the mudflats is not known, but was assuredly of substantial quantity. Part of the causeway was rebuilt between 1955 to 1959, contributing to the county's output of stone, sand and gravel.

Of all the non-metallic commodities produced in the county, the leading products are stone, sand and gravel, salt, and clays. This section provides more discussion on stone and salt. Stone is discussed as one of the most valuable commodities produced in Box Elder County. Salt is reviewed to provide variety as a non-construction commodity and to illuminate a resource with considerable development potential.

STONE

Stone has been used for tools and shelters since the beginning of man. Today we use stone for a wide array of purposes: limestone alone is used in thousands of products ranging from cement to chewing gum; dimension and crushed stone are used for constructing buildings, highways, and dams; and decorative stone is used for fireplaces, wall facings, and monuments, or it is crushed and used for landscaping.

Box Elder County is one of Utah's leading counties in stone production. Most of the stone quarried has been broken or crushed and used by the Southern Pacific Railroad. Consequently, the county's stone production increases noticeably in the years of the railroad's heaviest quarrying activities — when the railroad bed was completed in 1869, and during the 1902-1903 and 1955-1959 causeway construction. The most recent increase in crushed stone production occurred in the mid-1980s when dike-raising material was needed to protect the salt industries, roads, and railroads from the rising lake waters.

The large, angular fragments of rocks (riprap) are needed to protect the railroad causeway from wave erosion. Most of the stone quarried in Box Elder County during the mid-1980 high-water years was limestone used for this purpose.

The limestone quarried at Lakeside is mainly used to maintain the railroad causeway across the Great Salt Lake. This Mississippian-age limestone (Great Blue Limestone) is also used to produce lime, rock dust for coal mining, and soil conditioners.

Broken or crushed general-purpose stone is chosen for its cheapness, convenience, and durability. Limestone, dolomite, and quartzite are most often used, and these are plentiful in Box Elder County. Quarries at Lakeside, Lucin, and Promontory Point are conveniently located near the railroad bed. Crushed sandstone has also been produced in the county for riprap and refractories (materials used in furnace linings for example, that resist heat and chemical reactions in processing metal ores).

Dimension stone includes blocks, sheets, and slabs of any kind of rock, rough or worked, that provides width and length in structural, decorative, or monument construction. Quarrying the stone involves cutting large slabs or blocks from massive rock walls and later wedging the blocks into the desired sizes. Quartzite (mostly flagstone) is the leading dimension stone in the county and is primarily quarried in the Grouse Creek and Raft River Mountains. This quartzite is used locally as well as internationally. The common colors are gray, tan, or brown, with some bright green. Other dimension stone includes a white marble quarried at the north end of the Newfoundland Mountains. Some of this marble has been cut into slabs for sculpturing. Other types of rock in the county that could be used for dimension stone include granite, basalt, rhyolite, tuff, sandstone, limestone, and dolomite.

Ornamental stone is rock that can be cut into rough blocks and used for fireplaces, garden walls, fountains, and other decorative items. It is typically colorful or has interesting textures that make it attractive. Production at two quarries yielded pink and purple banded, welded tuff from the southern Goose Creek Mountains and yellow to tan, banded sandstone from the east side of the Pilot Range. Other potential ornamental rock types in the county include basalt, rhyolite, and tufa.

Crushed ornamental stone is rock of desirable colors and textures that is crushed into sizes ranging from small pebbles to one-inch gravel. It is used for roofing gravel,

Local quartzite and sandstone, as well as brick, were used in the construction of this historic tabernacle in Brigham City. The pioneers often used a combination of brick and stone to construct buildings.

landscaping, and in aquariums. Quartzite from Dove Creek Pass (between Rosette and Lynn), limestone and dolomite from the east side of the Newfoundland Mountains, and white marble from the north end of the Newfoundlands, have been quarried for crushed ornamental stone production.

SALT

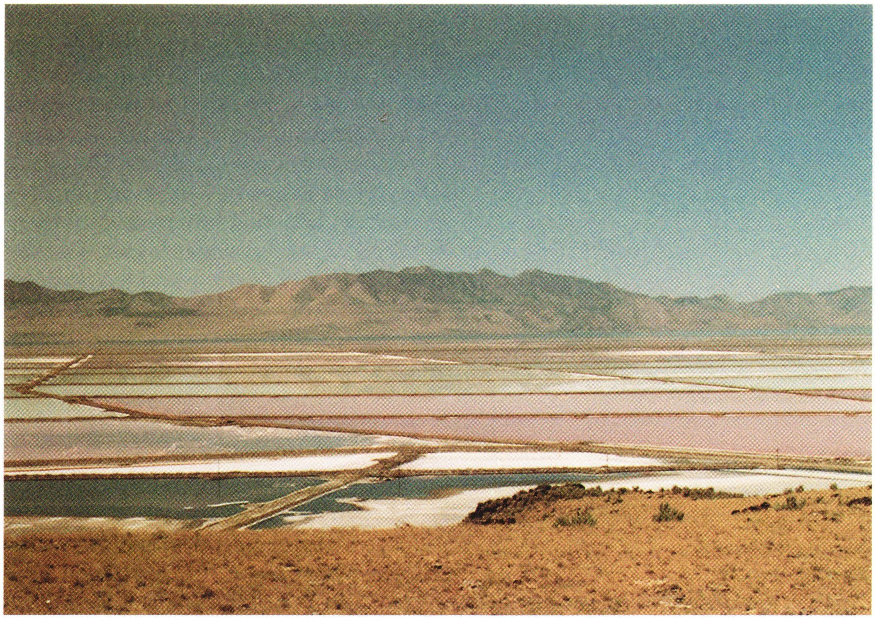
Salt is a mineral required in the diets of all vertebrate animals. All people from the most primitive to the most sophisticated consume salt. It is commonly supplied in blocks for cattle and other livestock. The importance of this mineral goes far back in human history. The ancient Hebrews, Greeks, and Romans used it as a religious offering; it influenced early domestic and world trade routes as a chief commodity; and it has 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 a mineral precipitated from natural brines in salt seas or lakes by evaporation of the water. In Box Elder County, salt is extracted from the Great Salt Lake through the use of solar evaporation ponds. The lake water is pumped into shallow man-made ponds where the water evaporates and the salt remains. Common salt, also known as sodium chloride or halite, is the principal salt produced from the lake. Other salts harvested from the lake include sodium sulfate (salt cake) and potassium sulfate (potash). Magnesium chloride brine is also extracted (see table 2). Lake elements that have potential to become important are lithium (electric batteries), bromine (chemicals), and boron (borax products).

The salt content of the Great Salt Lake averages about 25%. This figure varies according to climatic conditions, including precipitation, wind, water and air temperatures. During the mid-1980 wet years, the salt content dropped to a low of 6%. 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 (maximum depths vary between 25 and 45 feet, with the average depth being 13 feet when the lake level is at an elevation of 4200 feet), and the water covers a large surface area, evaporation can occur at a high rate. During dry years, the lake is sometimes a natural salt pan containing more salt than the water can hold. In the dry period of the early 1960s, the salt content was so high that an estimated one billion tons of salt precipitated out of the water and were deposited on the lake bed. Because this is not a common occurrence, the salt industries rely on their man-made solar evaporations ponds to extract the salt.

The lake's salt was used by the 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. Later, when production of larger quantities of salt was needed, large man-made solar evaporation ponds were constructed. The salt industry in Utah received its first real impetus from the discovery of silver in Montana in the mid-1860s. Salt was needed in the chlorination process to reduce the silver ores. Large tonnages of Utah salt were transported to Montana by trains.

Utah's main source of salt is the Great Salt Lake. The lake has an area of approximately 1500 square miles. It is the largest body of concentrated brine in the United States and is one of the most saline lakes in the world. More than one-half of the lake is contained within Box Elder County. Several of the salt operations in the county existed in Spring Bay.



Water from the Great Salt Lake is pumped into solar evaporation ponds (left). As the water evaporates in these shallow ponds, the salt remains and accumulates. The salt is then harvested by machine (below) and marketed for the salt we shake onto our food, water softeners, agricultural practices, ice control on the roads and sidewalks, soap manufacturing, food processing and preserving, and ice manufacturing.

This resource is unique in that it is virtually inexhaustible. The number of salt industries on the Great Salt Lake changes, and over the past 100 years there have been more than 20 salt operations. Although the north shore of the lake was never considered a prime area for salt industries due to its remote location, six salt industries, including one potash plant and an experimental lithium and magnesium extractor, operated in the county at various times. Salt ranked as one of Box Elder's leading commodities between 1957 and 1884.

East of Locomotive Springs, on the shore of Spring Bay, solar evaporations ponds were built by the Housel and Hopkins Salt Company. The location was chosen because it appeared that Corinne might develop into an important railroad junction and city of commerce when the transcontinental railroad was completed. There were reports of operation in 1871. Records are incomplete and the duration of this business is unknown.

North of Spring Bay, salt was produced by the Quaker Crystal Salt Company from 1939 to 1965. The salt came from three warm springs which began to flow after an earthquake occurred in the area. The salt was apparently suitable for cheese making. Since the location was near the lake shore, the company also extracted salt from the lake. Problems developed from fluctuating lake levels and vandalism, and the operations shut down in 1965 after a fire destroyed the mill.

During the late 1930s and early 1940s, the lake was at a low level and the brine was so concentrated that salt was deposited on the bottom of the lake. During this time, salt was recovered at Promontory Point on a small scale. The site was acquired by investors who intended to turn a small enterprise into a serious business. The business, named Lake Crystal Salt Company, began operations in 1947. For a while, this company had an advantage over other companies on the lake, because of the concentrated condition of the north arm of the lake (the north arm has less fresh water inflow than the south arm, and the brine became even more concentrated after the rock-filled causeway was completed in 1959). Although a small operation, it produced enough salt to place the commodity among the leading products of value in the county. It was one of five companies extracting common salt from the lake in the 1970s and early 1980s. All of the salt industries were affected by the rising lake level that began in 1983 due to high precipitation. Lake Crystal ceased operations in 1984 after its ponds flooded.

On the west side of the lake near Lakeside, Intermountain Chemicals built solar evaporation ponds. Operations began in 1969 and activity has been intermittent. The company experiments with magnesium and lithium production.

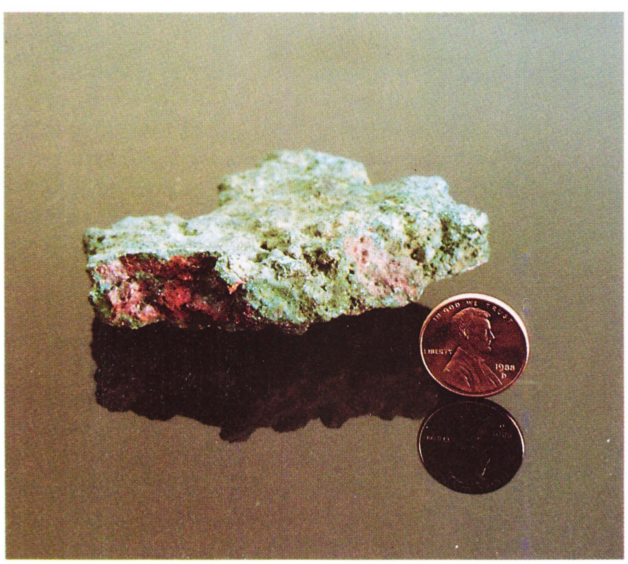
In 1970, Great Salt Lake Minerals and Chemicals Corporation began pumping brines from the north arm of the lake, around Promontory Point and east, to 19,500 acres of solar evaporation ponds on the eastern edge of Bear River Bay. Part of the ponding complex is in Box Elder County, but the U.S. Bureau of Mines credits production to Weber County. In addition to common salt, this company produces magnesium chloride brine, sodium sulfate (salt cake), and potassium sulfate (potash).

Flooded evaporation ponds. All of the salt industries on the Great Salt Lake are affected by fluctuating lake levels. Low lake levels require constructing canals and pumping brines to the ponds. High lake levels result in brine dilution and pond flooding. From 1983 to 1987, the lake level rose dramatically and industries looked for sources of more concentrated brine and new ponding areas which would be safe from the rising lake. Potential brine sources in Box Elder County that may be utilized include the more concentrated brine found at greater depths in the lake; the salt flat brines (muds and sediments of the Great Salt Lake Desert and mudflats surrounding parts of the Great Salt Lake that are saturated with saline water); and feasible solar ponding sites (large, flat areas with tight soil) that exist all around the northwestern part of the lake.

Spring Bay was also the location of West Kosmo, where a potash plant was in operation.

METALLIC RESOURCES

Metallic resources are those that have a metallic luster and are good conductors of heat and electricity. Metals occur naturally either as part of a mineral or alone. For example, copper is found both raw (unattached to other elements) or as one of many elements in over ten minerals found in the county. Metallic resources are usually of little use until they are mined and purified (refined) by technological processes.



Metallic ore deposits are created in a variety of ways through a series of geological forces. Typically, the original metal-bearing minerals are found in sedimentary or intrusive rocks. After they are deposited, the minerals are altered and moved by later igneous activity, heat, and pressure of metamorphism, and/or physical and chemical weathering. These secondary changes concentrate the once-dispersed metals into ore bodies.

Metallic ores were found in Box Elder County before the 1869 completion of the transcontinental railroad. Prior to this historic event, however, mining activity was rare since heavy ores like lead, copper, and iron were difficult to transport by wagon across the Great Salt Lake mudflats.

The first meaningful discovery of valuable metal ore in the county was in 1868 when native copper was discovered at the north end of the Pilot Range. In 1872, the Lucin mining district, named after a Central Pacific Railroad station, was organized around this discovery. Between 1886 and 1894, both copper and iron ore were mined in the district and shipped to Salt Lake City. The Lucin Mining District, the Ashbrook mining district in the Goose Creek Mountains, the Promontory mining district in the Promontory Mountains, and the Park Valley mining district in the Raft River Mountains are the four most important districts, in terms of metal production and value, in the county (the mining districts are located on the back cover map, Geologic Resources of Box Elder County).

Copper ore, mined and processed in Utah, had many uses. This photo shows raw copper as it appears when mined and copper that has been refined and minted into a penny.

Completion of the transcontinental railroad in 1869 encouraged increased mining activity in the United States as well as in Box Elder County. Photo courtesy of the Utah Historical Society.

The Park Valley District produced gold, copper, lead, and other metals from 1869, when activity first began, to the mid-1970s when the area was abandoned.

Metals played a significant economic and historic role in the county between 1870 and the early 1920s when the richest ores were mined. During those years, the county's mining districts yielded over eight million dollars. From the 1920s to the present, metal mining has been sporadic, reflecting fluctuating economic conditions. Through 1976, estimations suggest that at least 7,820,000 pounds of lead and 7,302,000 pounds of zinc were produced in the county. Total silver produced from the Ashbrook district, the fifth ranking silver producer in Utah for several years, exceeded 3 million ounces and over 7 thousand ounces of gold. Metallic ores extracted from the Park Valley mining area totaled about 16,4000 ounces of gold and over 1,000 ounces of silver. The Lucin district accounted for 18.2 million pounds of copper, over 262,000 ounces of silver, and 248 ounces of gold. Reports indicate that between 1870 and 1917 the total value of metals extracted from the Lucin district reached $3,256,200. Speculations also indicate that several million dollars worth of ore has been extracted since that date. Minor amounts of silver, gold, copper, and other related minerals were extracted from the remaining districts in the county. A complete list of Box Elder's metallic resources, the mining districts in which they were found, the type of ore deposits, associated minerals and everyday uses for each commodity is found in table 2.

Lead and zinc, two of man's oldest known metals, are selected for discussion below due to their long histories of extraction in northwestern Utah. Together, they are found in more than 12 mining districts in Box Elder County. Their contributions to the economic development and growth of the county are immeasurable.

Silver, frequently found in association with lead and zinc, is another important metal in Box Elder County. Throughout history, silver has held a position of status and has inspired miners, as well as artists. Silver exploration and mining brought untold numbers of miners and abundant wealth to the county.

LEAD-ZINC

Imagine this scene. A visit to your dentist included x-rays. During the procedure, the technician covered you with a lead "apron". Afterward, you drove home, grabbed a bowl of candy, and turned on the color television to watch your favorite program. You were probably unaware that these "run of the mill" activities are dependent on two important metallic commodities found in Box Elder County.

The dentist's shield, your automobile, and the color television all depend on lead. The lead apron is used as a protective barrier against radioactivity, the auto's electrical system depends on a lead-acid storage battery, and the color television tube is manufactured with lead. Zinc is used in your auto's break linings to provide maximum resistance to wear and in zinc die-cast parts such as carburetors, gages, pumps, mounts, and housings. Zinc compounds are also used in televisions and to purify the sugar used in candy.

Unique properties of each metal make them extremely useful in our society. Lead is a soft, heavy, corrosion-resistant metal. It is almost always found with zinc. Zinc has a low melting point, property that helps provide protection against wearing down of iron and steel, and the ability to alloy with copper to make brass. Galena, the primary ore mineral of lead, usually occurs in veins, pockets, and as limestone replacement deposits. The most common zinc mineral, sphalerite, is often found with lead and copper in veins and limestone replacement deposits. Both metals have long histories of use by numerous civilizations.

Galena, a lead mineral, is mined and processed into lead-weight fishing sinkers.

Lead is one of the earliest metals used by humans. A spinning bobbin, found in Russia dating from 5000 B.C., is one of the first known specimens of lead. Egyptians used lead sulfate for makeup and the Pharaoh's potters used lead to enhance the quality of their glazes. During ancient times, lead was used in bridge construction in Asia Minor, for flooring in the hanging gardens of Babylon, and for water pipes throughout the Roman Empire. Medieval uses expanded to include lead in leaded glass windows and in ornamentation.

Lead was first mined and smelted (refined) in the United States in the early 1620s. It was not mined on a large scale, however, until after the transcontinental railroad was completed in 1869. Through the 1920s, lead mining showed a general rise in production and in 1925, Utah produced the most lead in its history. After 1930, lead production in Utah gradually declined due to increased costs of mining deeper ores and the difficulty of locating new reserves.

Currently, there are no active lead mines in Box Elder County. In the past, however, the area was an important producer of the metal. Six mining districts that produced lead in Box Elder County, in order of importance, are Promontory, Lucin, Park Valley, Ashbrook, Rosebud, and Box Elder. Lead was also mined at Crater Island, Yost, and Newfoundland and ores have been located at Clear Creek, Sierra Madre, and Willard. Large tonnages of low-grade lead-silver-zinc ore still remain at Lucin. The Lucin and Promontory districts hold the most promise for future production of Box Elder County lead.

One of the earliest uses of zinc was as an alloy with copper to produce brass. Historians estimate that zinc was first used as early as 500 B.C. for making brass, jewelry, and in ornamentation (fountains, idols, etc.). During medieval times, zinc was used by alchemists who believed that it could be used to change copper into gold.

Although the use of zinc can be traced back to ancient civilizations, its use for industrial purposes in the United States is a relatively recent phenomenon. In 1835, small amounts of zinc were smelted from New Jersey ores for alloying into brass. Not until 1860, however, did technological advances enable large quantities of zinc to be produced. At that time, the demand for zinc was limited to its use as an alloy. Increased demand for the metal occurred in the late 1800s when galvanizing (coating iron and steel to stop rust) with zinc became desirable for wiring and roofing. Another boom occurred when the ammunitions industry was boosted by the onslaught of the Spanish-American War (1898). During this time, zinc was the fourth most widely used industrial metal. It is now used in galvanizing, as a chemical compound in paint and rubber, in the manufacture of fireworks, for removing silver from photographic solutions, and as an ingredient of compounds used to eliminate chimney soot.

In Box Elder County, zinc was produced with lead, silver, gold, and copper from the Box Elder, Lucin, Park Valley, Promontory, Tecoma, and Sierra Madre districts. The

Promontory district produced over 90% of the county's zinc since 1915 and, at times, ranked as the third largest zinc producer in the state. Both the Promontory and Lucin districts show promise for future production of zinc ores.

SILVER

One of the most important metallic resources in Box Elder County is silver. It is the whitest of all minerals, has high electrical and thermal conductivity, is very resistant to corrosion, is bendable, stretchable, and is capable of maintaining a high polish . Silver, used in historical times for utensils, jewelry, ornamentation, and as an item of barter, was so highly valued, that it became a monetary standard during the Roman Empire. It maintained a high status until the 16th and 17th centuries when large deposits were discovered in Mexico and Peru. It became even more abundant, and consequently less valuable, when additional large deposits were exploited in the 18th and 19th centuries. At that time, most countries stopped using it as a currency standard.

The Ashbrook Mining District has produced over 90% of the county's silver. It ranked as the fifth largest silver producer in Utah for several years. Production from the district amounted to about 3,192,666 ounces of silver ore, 7,762 ounces of gold, 3,001 pounds of copper, and 6,160 pounds of lead. Silver-bearing minerals in the area (table 2) were deposited and concentrated in limestones by hot solutions that accompanied igneous activity. Igneous rocks in the district include rhyolite and quartz latite porphyries. The first discovery of ore in the Ashbrook area was in 1872 and the district was organized in 1874. Property operations ceased in 1942.

Other silver-producing districts in the county include the Lucin (over 262,000 ounces of silver produced), Rosebud, Yost, Clear Creek, Sierra Madre, Willard, Tecoma, and Box Elder. Silver deposits were also found in the Crater Island, Park Valley (1,033 ounces of silver), Promontory (893 ounces of silver), and Newfoundland districts.

Although modern civilizations developed extensive uses for silver, it is still used in jewelry and ornamentation. This silver belt buckle features a center of variscite, a gemstone found in Box Elder County.

The Vipont area was the largest producer of the Ashbrook Mining District. Silver production from this area yielded the richest silver ore in the county.

ENERGY RESOURCES

Energy, the capacity to do work, exists in various forms. Heat energy (first discovered as fire) and manual energy are two of the oldest forms of energy used by man. Early people also used gravity (as the driving force in ancient aqueduct systems), the sun (to dry food and provide warmth), and wind and water (in ocean and river transportation) for energy sources. Fossil fuels (coal, oil, and gas) also played an early role in human history, both for energy and other applications: Egyptians used asphalt (a thick form of oil) in their mummification procedures, the Greeks poured oil onto the sea and ignited it to destroy enemy fleets, Romans and Greeks used coal for heating and lighting, and the North American Indians applied oil to the skin as a frostbite-preventative measure.

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 and freezer 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. Development and responsible use of our energy resources are essential parts of our lives.

Development of Utah's energy resources began in the mid 1800s with the discovery of coal. Coal remained the primary energy source until the 1950s when oil and gas replaced it as favorable sources of residential heat and industrial energy needs. More recently, uranium and geothermal energy have contributed significantly to Utah's resource base.

Past geological events in Box Elder County created environments favorable to the deposition of energy resources. Oil, natural gas, coal, uranium, and geothermal energy are all present in the county. The first four are found in sedimentary environments, and geothermal activity is associated with either the earth's normal geothermal gradient (temperature increases with depth in the earth) or igneous occurrences.

Oil, natural gas, and coal are fossil (organic) fuels. They provide the major supply of the world's energy. These fuels come from plants and animals that lived millions of years ago. When these plants and animals died and were buried, the hydrocarbon compounds contained in the living organisms altered into fossil fuels. In Box Elder County, oil has been found at Rozel Point. Gas production occurs from the Lake Bonneville sediments between the Wasatch Mountains and the Bear River Bay. Wells produced enough gas to provide heat, electricity, and hot water for five buildings near Brigham City between 1936 and 1949. A third well supplied fuel to a local gun club's facilities for nearly 40 years. Coal of lignite quality (low grade) is found in the Goose Creek and Grouse Creek basins (see Geologic Resource Map).

Uranium is in limited supply in the county. The most favorable geologic setting for finding uranium in the county is in the Tertiary Salt Lake Group lignites and carbonaceous shales. Geothermal activity is found in the eastern, northern, and northwestern parts of Box Elder County. The hot springs found along the Wasatch Front have been developed for commercial purposes. This section provides more discussion on this resource.

Oil seeps of Rozel Point led to early (1904) interest and drilling in the area. At least nine wells produced oil from Tertiary basalt.

Geothermal energy is natural heat energy contained in rock and fluid in the earth's crust. This energy transfers from deep to shallow regions when heated meteoric water (ground water) rises along faults and fractures. This action, known as hydrothermal convection, is displayed on the surface as hot springs, fumaroles, geysers, bubbling mudholes, and steam. The heat source for hydrothermal convection systems is either cooling igneous bodies or the earth's normal geothermal gradient.

Hot springs have been known and used since ancient times. Romans developed such areas for recreational and medical purposes all around the Mediterranean. Medical spas were also in existence in ancient Japan and elsewhere in the Far East. Since geothermal waters contain a variety of dissolved minerals, they are often considered to have medicinal value. Some of the water's minerals can be recovered economically. Interestingly, the first recorded commercial use of geothermal wells, which occurred in 1812 in Italy, was not for heating but for the production of boric acid.

Geothermally heated water is often used in commercially developed swimming pools. In Box Elder County, these pools are found at Crystal Hot Springs (above) and Belmont Hot Springs (below). The natural pond in the foreground at Belmont Hot Springs is spring-fed with cooler water than the water used for the pool seen in the background.

Today, high-temperature hydrothermal systems (greater than 300°F) are used to generate electricity. Direct uses of low-and moderate-temperature water (less than 300° F) include space heating for homes, public buildings, and greenhouses; water heating for resorts and spas; aquaculture (fish farming); heating in agricultural applications and mineral extraction; and refrigeration and air conditioning.

There are six major hot spring areas in Box Elder County: Crystal Hot Springs, Belmont (Udy) Hot Springs, Stinking Hot Springs, Utah Hot Springs, Coyote Hot Springs, and Etna Hot Springs. The first four listed are located along the Wasatch Front, which is a favorable area for discovery and development of local sources of low-temperature (less than 194°F) water (see Geologic Resources Map).

Waters from Crystal Hot Springs (134°F) and Belmont Hot Springs (110°F) are used for commercial swimming pools. Crystal Hot Springs is located ten miles north of Brigham City. Belmont Hot Springs is one mile southwest of Plymouth. Stinking Hot Springs (124°F), named after its pungent smell from hydrogen sulfide gas, hosts privately owned bathhouses. It is about six miles southwest of Bear River City. Utah Hot Springs (145°F) provided heat for a greenhouse producing hydroponic tomatoes and house plants. This geothermal area is west of Utah Route 89 on the Box Elder County -Weber County line. These four springs are located along Wasatch Front faults and probably result from deeply circulating water heated by the geothermal gradient.

The other two major hot springs in the county are located adjacent to large, extrusive igneous rocks. Coyote Hot Springs (110°F) is approximately five miles north of the Wildcat Hills in the northern part of the county. Etna Hot Springs (107°F) is near the western border of the county.

Geothermal energy is a resource with a promising future. It is an attractive, much less polluting energy source than the fossil fuels, and it is an almost limitless domestic source of energy. The technology to utilize this resource is only in the beginning phases of development, partly because geothermal systems exist at such great depths in most areas that they have been difficult to reach. In addition to generating electricity, geothermal heat will undoubtedly have increasingly important and diverse applications for direct use.

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Utah Mining Association, 1955, 1959, 1967, Utah's mining industry — and historical, operational and economic review: Utah Mining Association.

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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.

TABLE 1

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

Box Elder County Non-metallic Resources			
Commodity	**Uses**	**Location**	**Occurrence**
Barite	chemicals drilling glass paints rubber	Crater Island Grouse Creek Pilot Range Silver Island Mtns.	replacement or vein
Clays bentonite common clay	 drilling mud lining water structures bricks ceramics light-weight aggregate medicines tiles	 Hogup Mtns. Brigham City Goose Creek Mtns. Grouse Creek Mtns. Mantua Wasatch Mtns.	hydrothermal or sedimentary or weathering
Diatomite	absorbent drilling mud filler sugar refining wine refining	Crater Island Grassy Mtns. Hogup Mtns. Matlin Mtns.	Lake Bonneville deposit
Feldspar	abrasives ceramics glass	Raft River Mtns. Wasatch Mtns.	pegmatites
Gemstones chrysocolla gypsum crystals obsidian opalized tuff smithsonite variscite	 gems, ornamental curiosity arrowheads ornamental ornamental ornamental jewelry ornamental	 Lucin district Great Salt Lake Goose Creek Mtns. Promontory Point Goose Creek Mtns. Lucin district Hansel Mtns. Promontory Point Utahlite Hill	evaporite or igneous or vein or weathering
Kyanite	porcelain in spark plugs and in electric insulation refractories	Grouse Creek Mtns. Raft River Mtns.	metamorphic
Limestone/Dolomite	cement crushed stone dimension stone lime refractories riprap sugar refining	Deweyville Lakeside Lucin Raft River Mtns.	sedimentary

Magnesium Chloride Brine	chlorine gas drilling dust suppressant magnesium metal sugar beet processing	Great Salt Lake	brine
Mica	electrical equipment industrial products insulation soil conditioners	Grouse Creek Mtns. Raft River Mtns.	metamorphic or igneous (granite)
Oolitic Sand	acid neutralizer smelting flux	Great Salt Lake Lakeside Pigeon Mountain Promontory Point	sedimentary
Phosphate Rock	animal feed supplement chemicals fertilier	Goose Creek Mtns. Terrace Mtns.	sedimentary
Potash	fertilizer	Great Salt Lake Great Salt Lake Desert	evaporite
Salt	animal feed supplement food ice control on roads water softeners	Great Salt Lake Great Salt Lake Desert	evaporite
Sodium Sulfate	ceramics detergent filler paper	Great Salt Lake	evaporite
Sand and Gravel	aggregate for concrete construction fill filtration railroad ballast winter road safety	Lake Bonneville shorelines Wasatch Front	sedimentary
Silica	abrasives chemicals electronics filters glass refractories	Grouse Creek Mtns. Lakeside Mtns. Newfoundland Mtns. Pilot Mtns. Silver Island Mtns.	metamorphic (quartzite)
Stone	aggregate, construction aggregate, ornamental broken/crushed for railroad ballast riprap dimension stone for construction monuments ornamental stone	Dove Creek Mtns. Goose Creek Mtns. Grouse Creek Mtns. Lakeside Lucin Newfoundland Mtns. Pilot Range Promontory Point Raft River Mtns.	igneous or metamorphic or sedimentary
Tuff	pellet feed binder soil conditioner	Grouse Creek Mtns. Terrace Mtns.	igneous

TABLE 2

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

Box Elder County Metallic Resources

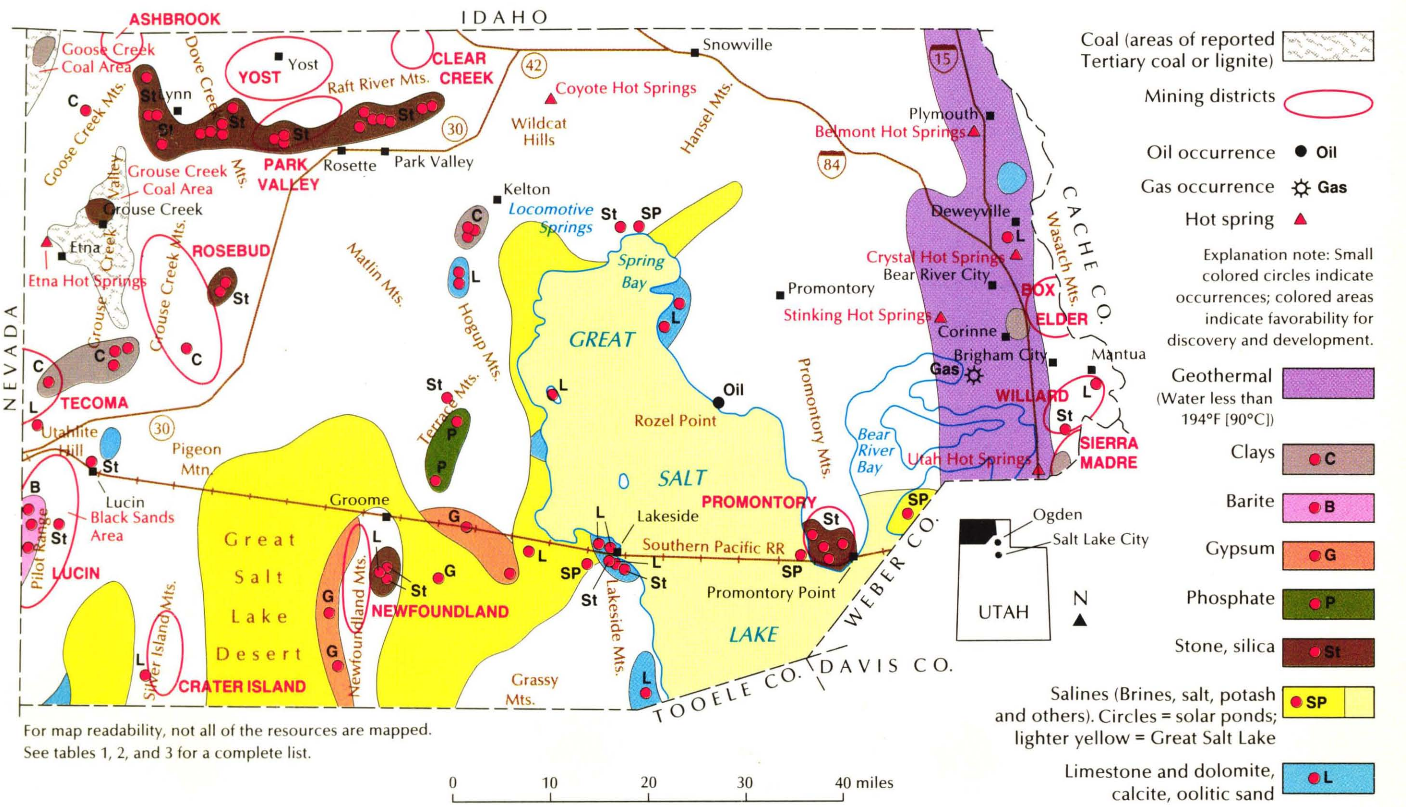
Commodity	Uses	Mining District	Occurrence	Ore Minerals	Associated Metals
Antimony	batteries ceramics flame retardant glass plastics	Box Elder Willard	vein/replace vein/replace	pyragyrite stibnite tetrahedrite	copper lead silver zinc
Bismuth	ceramics chemicals machine parts paints plastics	Newfoundland	vein	bismuthinite bismutite	copper gold lead tungsten
Copper	alloys ammunition coinage construction electrical prods. electronic prods. heat exchangers plumbing transportation	Ashbrook Box Elder Clear Creek Crater Island Lucin Newfoundland Park Valley Rosebud Sierra Madre Willard	replacement vein/replace replacement vein vein replacement vein/replace vein/replace	azurite bornite chalcopyrite copper cuprite malachite tetrahedrite	bismuth gold lead molybdenum silver zinc
Gold	currency dentistry electronics jewelry ornaments	Box Elder Clear Creek Crater Island Lucin Newfoundland Park Valley Rosebud Sierra Madre	vein vein vein vein vein	gold	bismuth copper lead molybdenum silver zinc
Iron	pig iron steel	Lucin Sierra Madre Willard	replacement vein/replace vein/replace	hematite limonite magnetite pyrite	copper lead zinc
Lead	batteries construction electrical prods. gas additive glass paint	Ashbrook Box Elder Clear Creek Crater Island Lucin Newfoundland Park Valley Rosebud Sierra Madre Willard Yost	replacement vein/replace vein/replace vein replacement vein/replace	cerussite galena vanadinite wulfenite	bismuth gold molybdenum silver zinc

Lithium	aluminum prods. ceramics glass lubricants	Great Salt Lake	brine		
Magnesium	aluminum alloys castings	Great Salt Lake	brine		
Molybdenum	aircraft automobiles chemicals machine tools	Crater Island Lucin Newfoundland	 vein vein	wulfenite	gold lead silver zinc
Silver	alloys dentistry electrical prods. electronics jewelry photography sterlingware	Ashbrook Box Elder Clear Creek Crater Island Lucin Newfoundland Rosebud Sierra Madre Tecoma Willard Yost	replacement vein/replace vein/replace vein replacement vein/replace replacement vein/replace	argentite cerargyrite pyragyrite silver tetrahedrite	copper gold lead zinc
Titanium	aircraft chemical process paint	Pilot Range	black sands granitic rocks	illmenite rutile sphene	
Tungsten	aerospace indust. drill bits dyes lighting television tubes	Crater Island Newfoundland Rosebud	 vein replacement	scheelite	lead molybdenum
Zinc	alloys brass construction electrical prods. machinery photocopying pigments	Box Elder Lucin Park Valley Promontory Sierra Madre Tecoma	vein/replace vein/replace vein vein/replace vein/replace replacement	hemimorphite smithsonite sphalerite tetrahedrite	copper gold lead silver

TABLE 3

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

Box Elder County Energy Resources			
Commodity	**Uses**	**Location**	**Occurrence**
Coal	fuels industrial products	Goose Creek Basin Grouse Creek Valley	lignite lignite
Gas	fuels plastics solvents	Great Salt Lake Basin	shallow Lake Bonneville sediments
Geothermal	electricity space heating water heating	Etna Wasatch Front Wildcat Hills	faults geothermal gradient igneous bodies
Oil	asphalt fuels solvents waxes	Great Salt Lake Basin Rozel Point	Tertiary basalt
Uranium	nuclear fuels nuclear weapons radioisotopes x-ray targets	Goose Creek Basin Raft River Mtns. Wasatch Mtns.	Tertiary lignites pegmatites pegmatites



GEOLOGIC RESOURCES OF BOX ELDER COUNTY, UTAH