GEOLOGIC RESOURCES OF SUMMIT 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 will introduce the reader to Summit County's geologic resources and their effect on our economy and daily lives. Understanding the dynamic forces that form geologic resources and the factors influencing their development and use helps us realize the value of our natural assets.

The county's resources are divided into three categories: 1) metallic, 2) non-metallic, and 3) energy. For simplicity purposes, this publication refers to resources as minerals, naturally occurring inorganic elements or compounds. It is important, however, to remember that a few substances do not belong in this category. Rocks, for example, are often made of more than one mineral and organic fuels which include natural gas, oil, and coal are not minerals.

Although there are numerous economic resources in Summit County, only a few have been selected for detailed discussion. The text will highlight the discovery, mining history, extraction, and common uses of these resources. Other county resources and pertinent data are listed in Tables 1, 2, and 3. In addition, a generalized geologic map, geologic time scale, and geologic resource map are included to aid your reading. A selected list of references is provided for those who are interested in further research. Additional information can be found by contacting or visiting the Utah Geological and Mineral Survey sales office and library.

CREDITS

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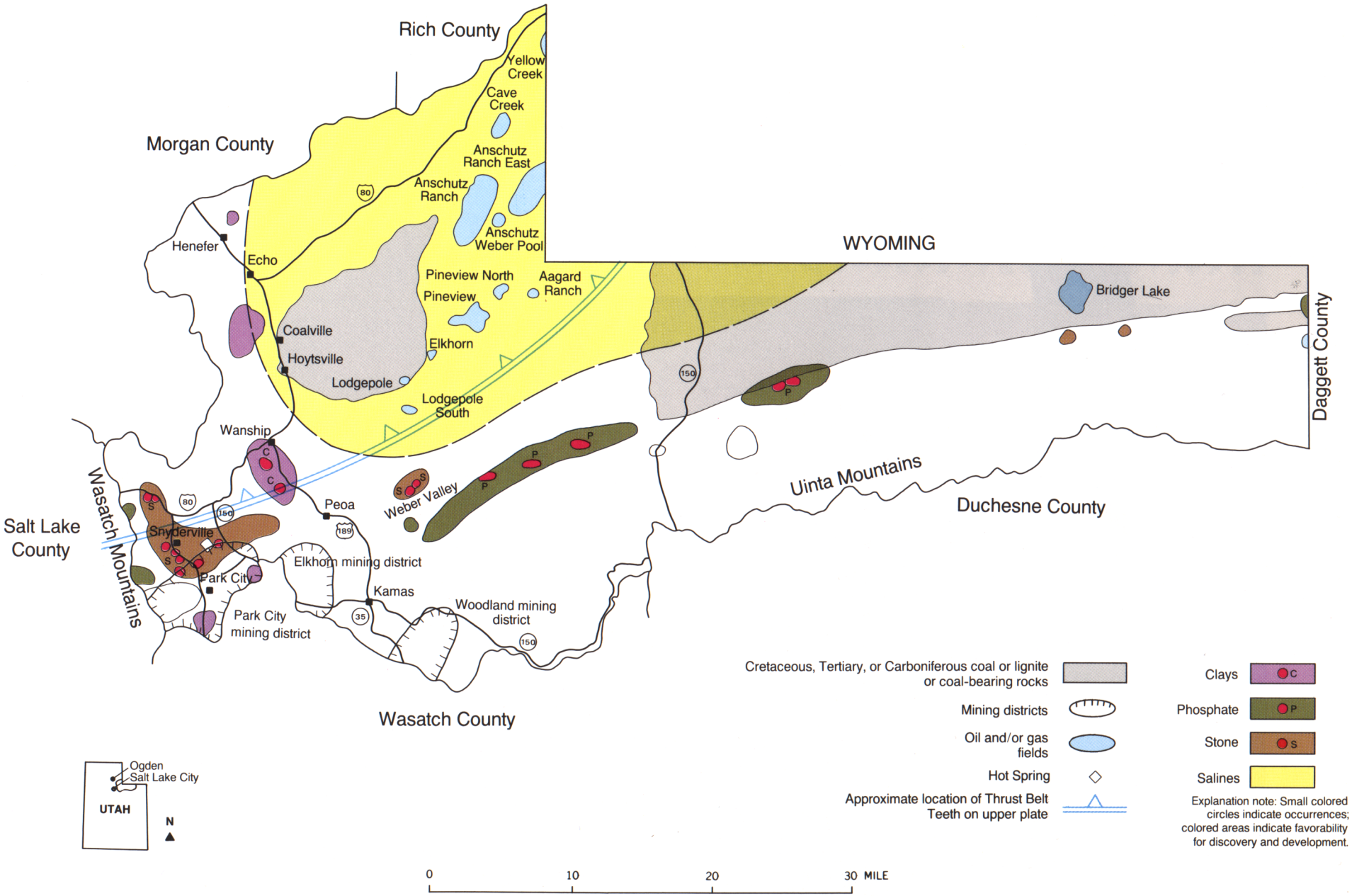


GEOLOGIC RESOURCES OF SUMMIT COUNTY, UTAH

INTRODUCTION

Spectacular scenery of Summit County is a direct by-product of the county's past geologic history. This scene of the high Uintas was sculpted by the carving action of ancient glaciers.

From the glacially sculpted scenery of the high Uintas to oil and gas reservoirs of the overthrust belt to the rich metals of the Park City mining district, Summit County has abundant geological resources. These natural assets make up an important part of the county's, as well as the state's economy. They provide an immediate supply of products for Utahns as well as contributing to domestic and foreign markets. Although the mineral market fluctuates depending on economic conditions, an increasing mineral output is needed to meet the demands of our ever-growing, complex civilization.

Various types of metallic, non-metallic, and energy resources are found in Summit County. Base and precious metals were among the first discovered in the area and probably rank as some of the county's most valuable holdings. Although not currently playing an active role in the economy, these resources provided Summit County with a colorful history and are closely tied to the promotion of local energy and non-metallic resources.

The growth and evolution of ancient and modern cultures is dependent on the earth's materials for shelters and weapons as well as for mediums in art and communication. Petroglyphs record histories and ancient customs of Utah's early inhabitants and visitors.

Although Utah's first settlers needed essential items like stone for buildings, clay for adobe bricks, lime for mortar, coal for heating, lead for bullets, and iron for tools and implements, they were discouraged from exploring for and mining precious metals. It was hoped that this philosophy would keep miners and other "undesirables" away from Utah.

Salt Lake Valley's population grew rapidly from the original 148 pioneers (arriving in 1847), to a population exceeding 140,000 by 1880. During this population surge, Salt Lake lacked adequate timber, grazing lands, and coal. These critical needs caused Utah's leaders to encourage settlers to explore the "Wasatch Mountain Valley" areas where metallic, non-metallic, and energy resources were soon discovered.

Everyone depends on natural resources. Our cars, bicycles, computers, almost everything we use is made with the earth's assets. This home was constructed with volcanic rocks from Wasatch County and Nugget Sandstone from Salt Lake County. Clay was used for mortar and in the sidewalks.

The list of resources used in our daily life is extensive. Salt is used in food and for ice control on roads. Copper, iron, lead, molybdenum, and other metals are used in automobiles, telephones, refrigerators, etc. This playground uses sand, limestone (cement), various metals, rubber (a petroleum by-product), oil, etc.

GEOLOGIC SETTING

The Uinta Mountains host some of Utah's most spectacular scenery as well as several of the highest peaks in the state. Along with scenery, the Uintas serve Utahns and tourists as a year-round recreational setting.

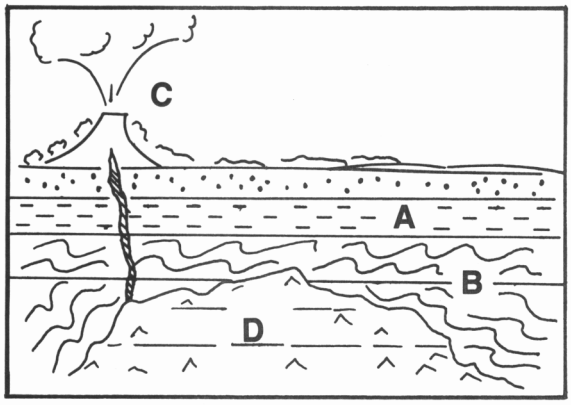
Summit County is called "Mountainland" because it lies along the backbone of the Wasatch Mountains. Two prominent ranges, the Uinta Mountains and the central Wasatch Mountains, make up most of the 1,860 square miles of the county. These ranges intersect near Park City within the Middle Rocky Mountain physiographic province (one of five distinct geographic regions in Utah). Like a gigantic vertebrae of our continent's spine, this province consists of a long ridge of mountains stretching from Canada to New Mexico. The rocks in the Utah segments of the Middle Rocky Mountains are folded, faulted, and sculpted by glaciers.

Both the geology and alignments of the Uinta and Wasatch mountains are unique. The Uintas are an east-west-trending anticline (an upside down, U-shaped fold where the rocks in the center are older than those on the limbs) whose rocks are mainly quartzites (metamorphosed or "baked" quartz sandstones). The north-south Wasatch Range is broken and shattered by numerous faults and in Summit County is mostly igneous rock (although sedimentary and metamorphic rocks can be found). The bedrock geology provides the framework for the different topography seen in each range: the Uintas, dominated by metamorphic and sedimentary rocks, appear more orderly than the slightly chaotic appearance of the sedimentary and igneous rocks of the Wasatch Mountains. In Summit County, the Wasatch Mountains slope gently into the Uintas. The alignment of the two ranges coincides with an extensive east-west bulge in the earth's crust called the Uinta Uplift. This massive structural feature, although incompletely understood by scientists, seems to be a localizing factor in numerous geologically significant events including thrust faulting, igenous intrusions, emplacement of metallic ore bodies, and steeply angled "normal" faulting.

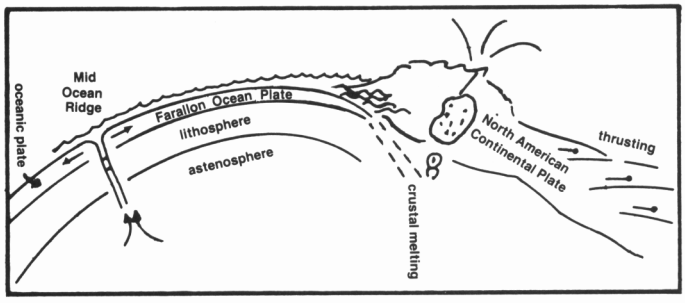
It is important to understand the geologic evolution of Summit County since mineral occurrences are the results of various geologic events. The oldest rocks in this complex area of Utah are between 1.4 billion and 800 million years old (Precambrian Uinta Mountain Group). These quartzites, quartz-rich sandstones, conglomerates, shales, and claystones reach up to 26,000 feet in thickness in the western portions of the Uinta Mountains and suggest a long period of basin filling.

Rocks that represent a span of time between about 800 million years ago to 550 million years ago (portions of the Precambrian and Cambrian epochs) are missing in Summit County. When scientists cannot find sections of the earth's rock history, they refer to the gaps in time as **unconformities.** These breaks in time suggest that the area was uplifted and eroded (similar to the Wasatch and Uinta mountains today). Detailed studies must be conducted to determine whether the missing layers were removed from the area by uplift and erosion or if the area was a topographic high during the time of deposition, preventing the layers from ever blanketing the area.

Five hundred and fifty to five hundred and thirty million-year-old Cambrian sediments, deposited after the extensive period of erosion, are represented by the Tintic Quartzite. At intervals beginning about 550 to 505 million years ago and lasting till about 150 million years ago (from the Cambrian to the middle of the Mesozoic era), shallow seas flooded the county leaving silts, muds, sands, and other sediments that would eventually host the ores of the Park City mining district and become the oil and gas reservoirs of Summit County's petroleum-rich overthrust belt.



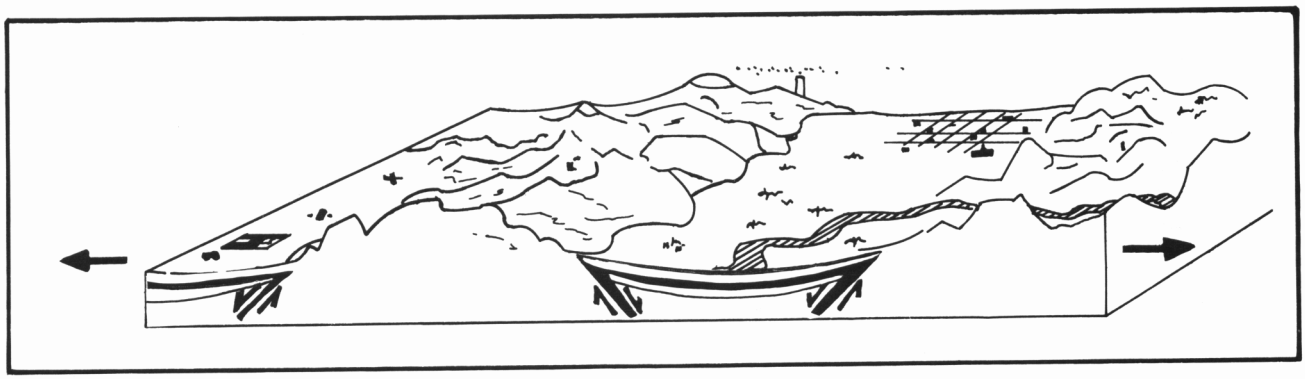
Three general classes of rock are: (A) sedimentary, (B) metamorphic, and (C and D) igneous. Igneous rocks are divided into extrusive (C) and intrusive (D). Extrusive rocks spew onto the earth's surface and are usually molten, or flow onto the ground before they cool and solidify. Volcanic lavas are extrusive. Intrusives are chemically the same as extrusives but they cool and solidify before reaching the surface. After cooling and solidifying, erosion of the overlying rocks, faulting, or other upward forces bring intrusive rocks to the surface. Sedimentary rocks form when particles accumulate in air or water and eventually cement together. Metamorphics are sedimentary or igneous rocks that have been changed by exposure to intense pressures and temperatures.



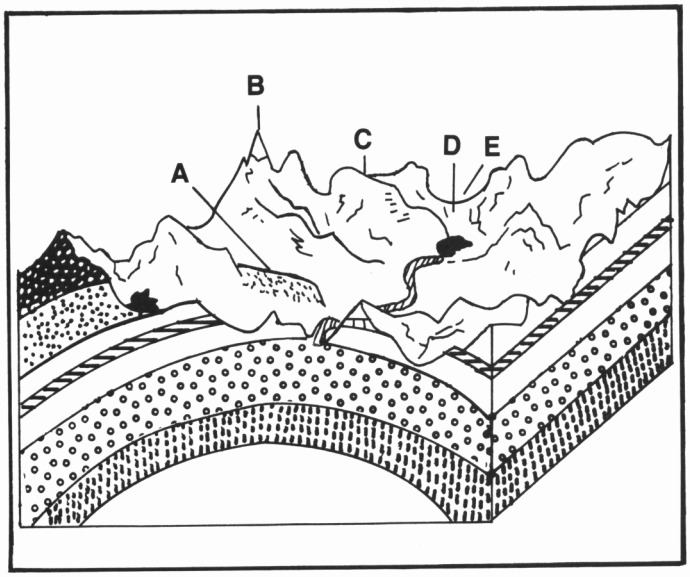
About 65 million years ago, a large crustal plate of ocean rocks (the Farallon Plate) crashed into the North American continent. The collision created intense compressional forces that pushed large slabs of rocks (originally deposited in basins to the west) to be moved eastward. "Thrust" faults formed during this time and can be seen in Summit County. They are related to the county's oil, gas, and metallic resources.

In addition to deposition and erosion, the surface of the earth is subjected to pushing and pulling forces that impose various types of geologic marks or fingerprints. These scars on the earth's face are referred to as "structures." Collision of two of the earth's plates caused the formation of a belt of squeezing-type structures in the western United States from about 65 to 40 million years ago. In Summit County, these structures include folding (bending) large blocks of the crust and thrusting (breaking) large sections of the crust from west to east by pushing forces. These compressional events formed "traps" for oil, gas, and water to accumulate in the overthrust belt (see the oil and gas section for explanation).

Much of Summit County's geologic history from 65 million years ago up to the present (Cenozoic Era) was characterized by volcanism, faulting, and glaciation. Igneous centers were active between 35 and 32 million years ago (mid-Tertiary time) and left intrusive rocks, angular fragments explosively ejected from volcanoes, ashes, and hot flowing molten lavas of the Keetley volcanics. From 15 to 10 million years ago (late Tertiary), the area to the west of Summit County began breaking into large blocks, causing the reactivation of older structures and creating numerous new "normal," or steeply dipping, faults. These "extensional" forces caused the landscapes to change significantly. Massive segments of the earth's crust moved up relative to adjacent blocks, creating a series of parallel mountains (horst) and valleys (graben). Continental "stretching" continues today and evidence for it can best be seen in the Basin and Range physiographic province to the west of Summit County. This province is characterized by chains of mountain ranges that, like the needle in a compass, point north-south and are separated by long valleys. Although Summit County is not a part of this province, it was subjected to these same forces and hosts numerous faults that formed during this period.



From 30 and 25 million years ago, squeezing forces that had previously been exerted on North America relaxed and portions of the plate began to separate. As a result, rocks in central and western Utah formed numerous sets of steep zones of breakage. "Normal" faults form when extensional forces cause large blocks of the earth to move down (valleys) relative to adjacent blocks (mountains).



Glacial features include: (A) Moraine, rocks and debris left by a moving or melting glacier; (B) Horn, a pyramid-shaped peak formed by the walls of three or more cirques; (C) Arete, a knife-edged ridge that formed when cirque glaciers met and eroded the ridge from two or more sides; (D) Cirque, a steep-walled basin carved by scooping action of glacial ice; (E) Col, a gap in a mountain pass where headwalls of two cirques intersect. This diagram, like the Uintas, has an anticlinal structure.

Glaciation occurred between 30,000 and 8,000 years ago (Quaternary time). Large masses of ice carved parts of the newly formed mountains and left terminal (end) and lateral (side) moraines throughout much of northern Utah's mountains and valleys. The two ranges (Uinta and Wasatch) in Summit County were the most glaciated areas of the state during early Quaternary time. Spectacular topographic expressions of the ice-age can be seen throughout the county. U-shaped valleys, cirques, glacial lakes, aretes, cols, and moraines are found in both the Uintas and Wasatch. The central Uinta Mountains have the largest area of glacial scenery in Utah and contain the High Uintas Primitive Area.

All of these complex geologic processes combined to give Summit County its economic resources. The county's metallic ore deposits occur in veins and bedded replacement deposits in sedimentary, metamorphic, and igneous rocks that are 350 to 30 million years old. Unique rock types and structures provided the county with abundant energy resources. Silver, gold, lead, zinc, oil, gas, sand, gravel, and many other geologic resources played a big role in the economic evolution and growth of the county. All known economic resources are listed in Tables 1, 2, and 3. Although each commodity has unique qualities, only a few from each category are listed in detail. They are chosen for their significance to the county.

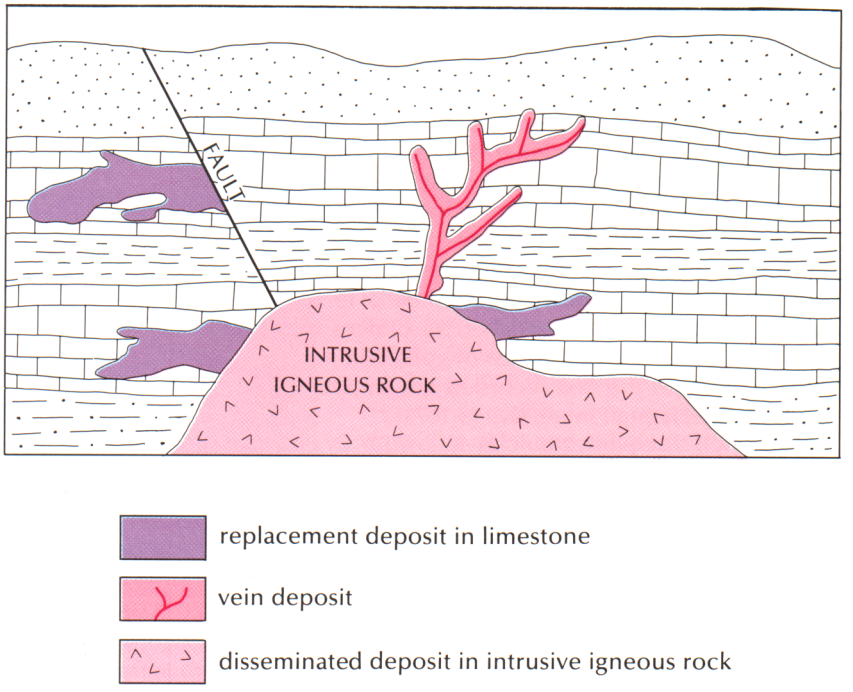
METALLIC RESOURCES

A common metallic mineral, copper, is mined and processed in Utah and has many uses. This photo shows raw copper as it appears when mined and copper that has been refined and minted into a penny.

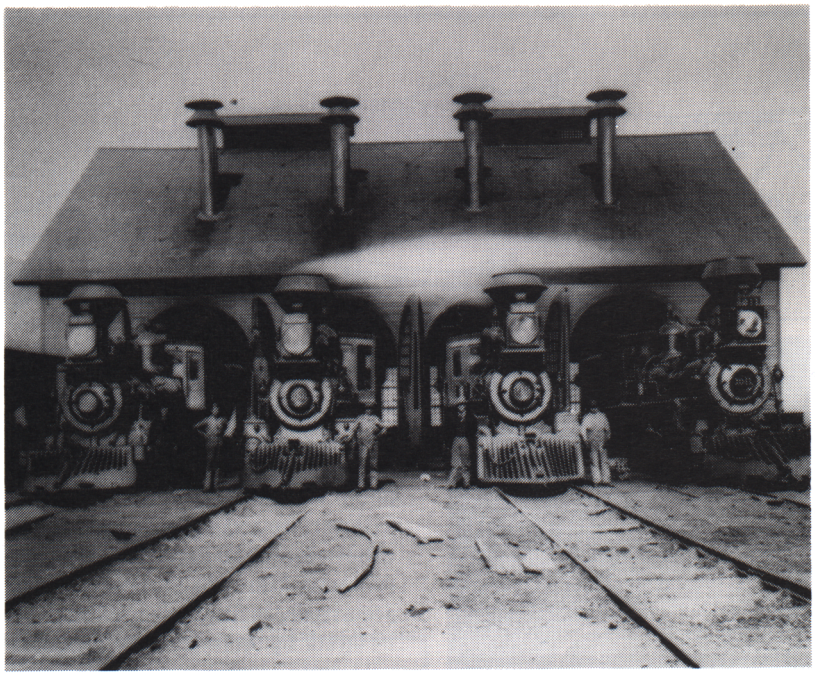
Almost everyone is familiar with the lure of gold, silver, and other precious metals, but what defines a metal and sets it apart from building stone, salt, gems, gilsonite, etc? Metallic resources have a shiny, metallic luster, and are good conductors of heat and electricity. Metals occur naturally, either as a part of a mineral or alone. Copper, for example, is found both raw (unattached to other elements) or as one of many elements in over 15 minerals found in Summit County. Metallic resources are usually of little use until they are mined and purified (refined) by technological processes.

Metallic ore deposits form in a variety of ways. In general, scientists believe that buried igneous activity either brought the metallic minerals into the existing rocks, or served as the heating system that mobilized and reconcentrated minerals that already existed in the sediments. Heat and pressure of metamorphism as well as physical and chemical weathering can also serve to focus the originally scattered metals into densely concentrated ore bodies.

Summit County's major source of metallic commodities is the Park City mining district. The district has several ore bodies distributed over a large area. Rich concentrations of silver, lead, zinc, copper, and gold are found along contacts between layers of bedded rocks and in and around cracks, veins, and faults in igneous, sedimentary and metamorphic rocks. The ores occur in three northeast-southwest zones that cross the center of the Park City anticline. These zones include the Silver King to the north, the Ontario in the center (Ontario mines provided high-grade silver ores for a distance of over 5,000 feet and a depth of 1,300 feet), and the Mayflower to the south. Most of the replaced (ores that move into and supplant the original rock material) ores from this area are found in the Permian-age Park City Formation.



Metallic ores are deposited in and mined from three different geometric configurations. Most of the ores of the Park City mining district were replacement and vein deposits.



Railroads transported metallic ores and coal to markets in Salt Lake and Ogden. This Echo, Utah roundhouse was built about 1880, the first one in the state. Photo courtesy Utah Historical Society.

Historical records suggest that Spanish expeditions (the 1776 Dominguez-Escalante expedition was the first to reach Utah) dabbled in Utah mining activities. Little, however, is known about the locations of their workings or successes and failures. The best records of mining history in Summit County are from the 1800s. In the winter of 1869, ore was first discovered in the Park City area of Summit County. Numerous stories and legends evolved around the initial discovery. One story attributes the discovery to Colonel Patrick E. Connor's soldiers. While walking in the mountains about two miles from Park City, a few of his men discovered and sampled an outcrop with a quartz vein that appeared to bear precious metals. The soldiers marked the sample site by erecting a dead log and tying a bandana to it. Initial assays from the sample contained 96 ounces of silver, 54% lead, and one-tenth ounce of gold. Mining began immediately and the first recorded ore shipment from this area, the Flagstaff mine, was in 1871.

Other rich discoveries quickly followed. By November of 1869, the Mountain Lake and Uinta districts were organized. Metallic ores were found in Walker and Webster Gulch, the McHenry Gulch, and the Jones Bonanza (Daly-Judge mine). In 1871, lead ores with assays of 30 to 250 ounces to the ton were removed from the Pinon mine.

Owners of the Pinon contracted to deliver up to 20 tons per day to an Ogden smelter. The rich Ontario mine ores were located in 1872 and displayed assays of up to 400 ounces of silver to the ton. Less than twenty years later, Silver King lead-silver ores were struck. They eventually rivaled all other Summit County deposits in both quantity and quality.

Metals production (excluding iron) in Summit-Wasatch Counties amounted to about $50,000 per year before the introduction of railroads. In 1869, completion of the Union Pacific Railroad provided efficient transportation to metal markets, allowing the Park City mining district to intermittently rank as the second largest producer of lead and zinc in Utah. By 1880, Park City was a large town with concentrators, homes, and businesses. The combination of fires, prohibition, World War I, a slump in silver prices, the depresssion, and labor problems contributed to the ultimate decline of Park City as a mining mecca.

The district's underground mine workings are over 800 miles long and ore values from the district exceeded $476 million. In 1953, the largest producing mines in the Park City district (Ontario, Daly-Judge, Silver King, etc.) were united under the name of United Park City Mines Company. Properties were first operated by joint venture of Anaconda and Asarco Inc. and later by Noranda Mines Ltd. The Park City district operated almost continuously from the 1870s to 1982 when the major underground operations in the district were shut down.

SILVER

One of the most important metallic resources of Summit County is silver. It is the whitest of all the metals, a great conductor of heat and electricity, resistant to corrosion, bendable, stretchable, and is capable of maintaining a high polish. Silver, used in utensils, jewelry, ornamentation, and in historical time 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. Increases in abundance and availability made it even less valuable when additional large deposits were located in the 18th and 19th centuries. At that time, most countries stopped using it as a currency standard.

The Park City mining district was a giant producer of silver. Two mammoth mines in the district became famous for their large quantities of rich silver ore. In addition to silver, the Ontario and the Silver King mines extracted gold, lead, zinc, and copper ores. From 1875-1967, total silver production from the Ontario mine exceeded 56,950,000 ounces with an average grade of 22.7 ounces per ton. During the same period, total silver produced from the Silver King amounted to over 86,120,000 ounces, with an average grade of 18.33 ounces per ton. Total silver production for the entire district for those years was 249,190,289 ounces.

The age-old quest for silver encouraged prospecting and ultimately rich discoveries in Utah. Today, silver is used in jewelry, utensils, photographic and x-ray film, photocopying paper, mirrors, dentistry, etc.

Miners experienced many hardships and went to unimagined lengths to extract riches. This photo shows the dark, dreary interior of the Ontario mine. Photo courtesy Utah Historical Society.

Ores of the Ontario mine were discovered in 1872. Initial assays reported 100 to 400 ounces of silver to the ton. Within weeks of the discovery, the claims were sold to George Hearst, providing the basis for the Hearst family fortune. This historic $30,000 purchase ultimately yielded over $50,000,000 of ore. Under Hearst's direction, large quantities of ore were extracted and shipped to Salt Lake Valley smelters by wagon. The Ontario Silver Mining Company was incorporated in 1876 with $10,000,000 in stock. At that time, it was the territory's richest producer.

Construction of a large 40-stamp mill near the mouth of Ontario Canyon was completed in 1877. This new mill, together with the local McHenry Mill, processed Ontario ores as quickly and efficiently as possible. Silver, however, was so abundant that refining could not keep pace with mining. Eventually, some of the highest grade ores were shipped to Liverpool, England for processing. By 1892, however, competition from adjacent mines sprang up and the Anchor mine and the Daly mine ranked along with the Ontario as the area's largest producers.

In 1888, two miners, returning to the Park City area from a fishing trip, crossed Walker and Webster Gulch and followed a nearby ledge. Eight hundred feet from their cabin, they located a boulder that appeared rich in silver ore. Assays of 600 ounces of silver to the ton sparked interest in the area that lead to the discovery of the richest producer in the history of the Park City mining district, the Silver King mine. Located on Treasure Hill, the Silver King provided the fortune for the Kearns wealth (The Thomas Kearns Mansion, located on South Temple in Salt Lake City currently serves as Utah's governor's mansion) as well as that of Mrs. Emery-Holmes-Delitch-Engalitcheff, Utah's Silver Queen (she earned $1,000 per day in silver).

Fluctuating silver prices and labor problems caused the Silver King to operate intermittently, but it maintained its status as the king of Summit County silver producers.

Mrs. Susanna Egeria Bransford Emery Holms Delitch Engalitcheff was known as Utah's Silver Queen. Her wealth came from Park City silver ores and catapulted her into the international social scene. Her passion for silver was legendary. Even the door knobs of her Salt Lake City mansion were solid silver.

NON–METALLIC RESOURCES

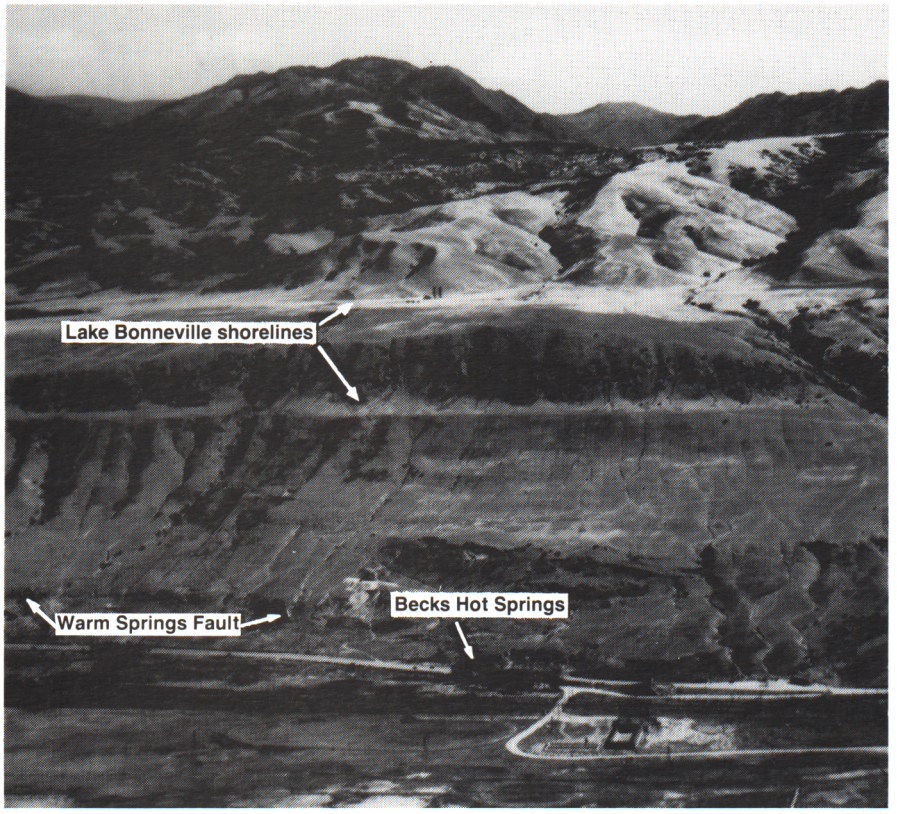


Photo credit: Utah Historical Society.

Northern Utah's extensive sand and gravel resources were deposited by glacial action as well as by the waters of ancient Lake Bonneville. This photo shows terraces formed by Lake Bonneville shorelines. These deposits of sands and gravels rim the basins that contained the lake waters. Like bathtub "rings" the lake's waters left rings of beach sediments. Massive deposits along with long histories of extraction and use have made sand and gravel important valuable commodities throughout Utah.

Non-metallic or "industrial" resources include the rocks and materials that are not processed for their metal content or used as fuels. They are familiar sights in everyday life. Sand boxes, gravel roads, brick or stone fireplaces, pottery, and stone walls are common examples of uses for industrial commodities. Summit County's list of non-metallics includes dimension and ornamental stones, jasperized chert and horn coral gemstones (from limestones in the Woodland area), sulfur, oolitic limestone, phosphate rock, etc.

Non-metallic commodities are formed by several geologic processes including igneous, sedimentary, metamorphic, weathering, and ground-water movement. For example, mica, considered petrified lightning flashes by ancient civilizations, is a product of metamorphic and igneous processes. Sand and gravel are deposited by the erosional action of water or glaciers. Building stones can be sedimentary rocks, like those from the sandstone quarries near Snyderville, metamorphic rocks, or igneous rocks like the granite quarried near Peoa. In Summit County, the leading non-metallic commodities produced from mid-1970 through mid-1980 include clays, stone, sand, and gravel (U.S. Bureau of Mines).

Clay and stone are highlighted in this text because they were among the earliest resources used by our ancestors. To this day, they maintain a prominent status in Utah's construction industry. Summit County clay, initially exploited in the early 1900s, is still used by local brick manufacturing companies. Stone, quarried at various sites throughout the county, was essential to the construction of several early buildings and is still used for walls, walkways, and facades of modern buildings.

CLAY

Without clay, tennis players, skeet shooters, and even luxurious spas would lack vital tools. Some of the world's best tennis courts have clay surfaces, skeet shooters take aim at clay pigeons, and spas offer "mud" (clay) baths as a beauty technique. Clays, used for centuries by potters and other artisans, are naturally occurring earthy substances with very fine particles that stick together. When wet, clays become slippery and plastic (like children's "play-dough"). Clays form when other minerals "weather," or are chemically changed when hot gases and solutions emanate from buried igneous intrusions, or by sedimentary deposition. They vary widely in chemical composition and are found in a wide range of colors.

Today, clays are still used in pottery and sculptures, but uses have expanded to include those mentioned above, as well as in ceramics, cosmetics, medicine (kaolin and bentonite in Kaopectate®), drilling muds, and as protective linings in reservoirs and canals. The specific type of clay and its mineral composition determines its use and resulting value.

Clay, quarried from the Henefer (7 miles north of Coalville) area since 1913, is a mixture of kaolinite, muscovite (mica), quartz, feldspar, and iron. The rusty red to reddish chocolate brown silty clays are actually deposits of siltstone containing clay from the 80-million-year old Henefer Formation (of Cretaceous age). The clay mined at Henefer is used in the manufacture of sewer pipe, red fire brick, and structural clay products like large bricks for high-strength uses. Henefer clays are also used throughout Utah as a primary component of several baseball diamonds. Once extracted by local Utah brick companies, the clay deposits are now used for a Summit County sanitary landfill.

Clay plays a major role in our modern society. Often thought of as a medium of art (pottery, sculpture, etc.) and construction (mortar, cement, etc.), it is also used in foods, medicines, beauty aids, tennis courts, and a multitude of other things. Clay was one of the first natural resources used and is still popular today.

STONE

Throughout history, the availability, durability and spectacular colors of stone met primitive needs and inspired artistic creations. Stone has been used for tools, shelters, ornamentation, and utensils since mankind's beginnings. Pyramids, carved figurines, jewels and clay pots of all cultures are monuments to the durability and beauty of rocks of the earth's crust.

There are three classes of stone. **Igneous** rocks hardened from hot, thick fluids that invaded the earth at various depths or spewed from the throat of a volcano. **Sedimentary** rocks are layers of debris whose particles (either very small like those in shale or large like components of conglomerate) cement together over time. Sedimentary "beds" accumulate when particles precipitate out of water or are eroded from landforms. **Metamorphic** rocks begin as sedimentary or igneous rocks. Exposure to increased temperatures and/or pressures initiates chemical, textural, and physical changes that alter or "metamorphose" the properties of the original rocks.

Modern civilizations continue to depend on stone for many uses. Limestone, for example, is used in both cement and chewing gum. Dimension and crushed stones are used for landscaping, and constructing buildings, highways, and dams; and decorative stone is used for fireplaces, wall facings, and monuments, or it is crushed and used to decorate structures.

Dimension stone includes blocks, sheets, and slabs of any kind of rough or worked rock that provides width and length in structural, decorative, or monumental construction. Sandstone is the leading dimension stone in Summit County. Between 1900 and 1962, Summit County, along with 12 other Utah counties, produced about $16 million worth of sandstone. Reddish to cream colored Nugget Sandstone (deposited 200 to 180 million years ago) has been quarried near the towns of Snyderville and Park City. It can be seen on facades in numerous Summit County buildings, as stone fences, and as masonry bases for numerous buildings constructed in the late 1800s. Other prominent northern Utah buildings constructed out of Nugget Sandstone include numerous historic Fort Douglas structures, the foundation of the Salt Lake City Mormon Church Tabernacle, and St. Mark's Cathedral in Salt Lake City.

Other Summit County building stone reserves include the 100- to 80-million-year-old (upper Cretaceous) Frontier Sandstone; small, poorly developed marble deposits; and a small granite quarry near Peoa.

Quarried stone was used to build many of Utah's historic structures. This photo of the Little Cottonwood Canyon quartz monzonite quarry shows workers cutting large blocks from massive rock walls. The blocks were later wedged into more desirable sizes. Photo courtesy Utah Historical Society.

The county courthouse in Coalville is a magnificent example of the beauty and durability of locally quarried building stone.

ENERGY

Energy, the capacity to do work, exists in various forms. Humans have relied on heat and manual energy longer than any other forms. Early people also have used gravity (as the driving force in aqueduct systems), the sun, wind, and water for energy sources. Fossil fuels (coal, oil, gas, tar sands, etc.) 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 Indian applied oil to the skin as a frostbite-preventative measure.

At the turn of the century, energy forms were still primitive. Horses pulled empty ore cars into mines. When full, the cars used gravity to coast down to the mills and refineries. Photo courtesy Utah Historical Society.

Energy demands increased as civilizations grew in size and sophistication. Competition motivated people to seek ways of performing tasks faster and better. More efficient forms of energy evolved that are used daily: gas and electric heat in our homes replaced wood and coal for heating; fuel-powered transportation replaced walking and animal transit; and electric freezers and refrigerators replaced root cellars as efficient methods of food storage. 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 consumption and management. Development and responsible use of our resources are essential parts of our daily lives.

Oil, natural gas, coal, uranium, and geothermal steam and water are all found in Summit County, but fossil fuels are probably the most important energy resources in the area. They are selected for discussion in this report because petroleum and coal have long histories of use and have contributed significantly to the county's economic development.

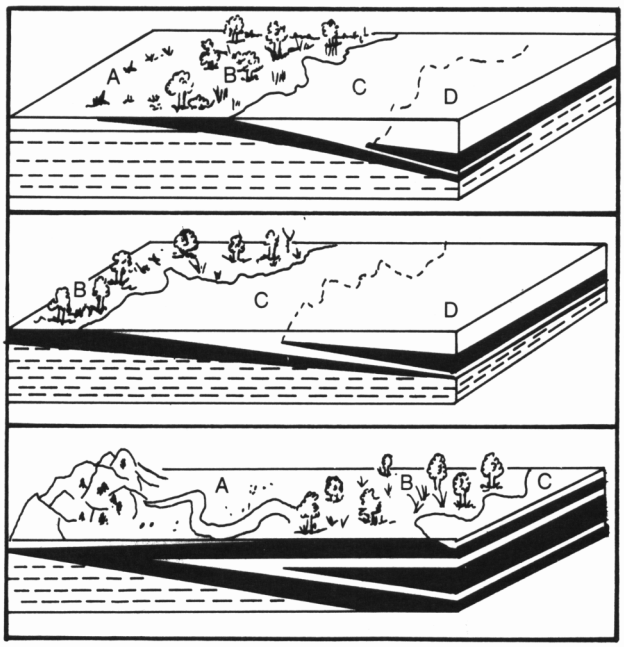
COAL

Coal is a sedimentary rock that is mostly composed of carbon. This energy source forms by partial or complete decay of plants that lived millions of years ago. When the plants died and were buried, heat and pressure caused the hydrocarbon compounds contained in the living organisms to alter into "fossil fuels," a family of which coal is a member. Coal's chain of decomposition begins with buried plants which alter to peat, to lignite, to bituminous coal, to anthracite, and to graphite.

From about 100 to 65 million years ago (during Cretaceous time), Summit County's coal deposits began forming. The environment around Coalville was similar to that of a swampy coastal plain. Highlands or mountains in the west (created by the Sevier orogeny) provided a source of erosional materials that were deposited on the plains. Gently sloping plains eventually met marine waters that blanketed the land to the east. The water transgressed and regressed (flooded and subsided) cyclically burying swamp and flood plain vegetation with each cycle. These layered sediments eventually hardened to rock and formed Coalville's coal deposits.

The Coalville field, one of the oldest coal mining districts in Utah, is located in a nine-by-seven-mile area in western Summit County. It is one of two coal fields in the county. Coal near Coalville is found in at least 18,000 feet of folded Cretaceous and Tertiary rocks in the western portion of the county. The fuel, classified as subbituminous A for the amount of heat it can produce, has a high ash fusibility, crumbles with exposure to air, and is highly susceptible to spontaneous combustion.

The Coalville field has an interesting history of discovery and development. Settlements grew rapidly in the Salt Lake Valley and so did the need for heating fuel. Insufficient timber near Salt Lake City encouraged Utah's 1854 territorial legislature to offer a $1,000.00 award for the first discovery of coal within 40 miles of Salt Lake. By 1859, coal was extracted from the hills near Coalville. From 1870 to the turn of the century, the Park City mining district's need for fuel provided a steady market for this energy source. By 1873, coal was shipped to Salt Lake via the Summit County Railroad, an independent narrow-gage road over Parleys Summit. Coal production reached about 30,000 tons by 1880 and swelled to a 75,000-ton maximum by the turn of the century. After 1900, railroads provided northern Utah with better quality coal (from Wyoming and central Utah) and all but two mines closed in Coalville. Mining, for industrial purposes, continued off and on until all operations stopped in 1988.

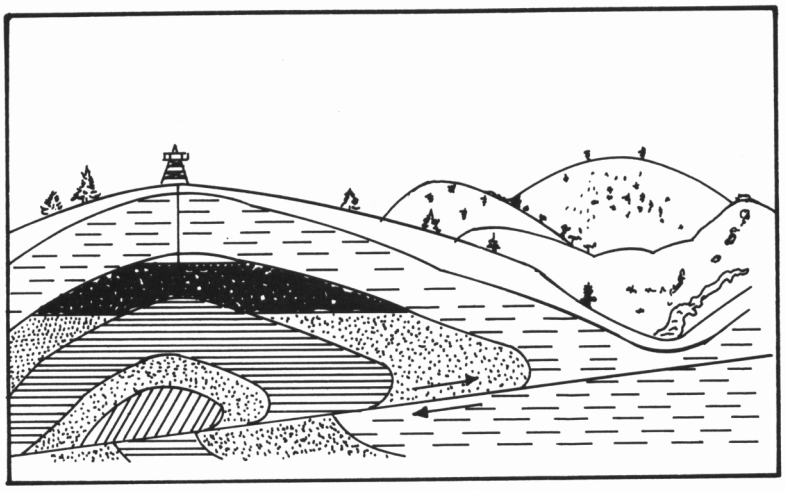


Coal is often deposited in swampy coastal plains. These three diagrams show an encroaching and retreating sea with (A) flood plain; (B) swamps; (C) shallow waters; and (D) deep waters.

Summit County's other coal field is the Henry's Fork. It is located along the northern side of the Uinta Mountains and consists of a series of small coal-bearing areas. This coal, considerably older than that of the Coalville area, is found in several formations but was mined only from the approximately 340 to 320 million-year-old Manning Canyon Shale (of Mississippian age). These shales were deposited by warm, shallow waters that invaded north-central Utah. Coal mining in this area ceased in the mid-1900s.

OIL AND GAS

Petroleum (oil and gas) can be a liquid, solid, or a gas. It occurs naturally and is mostly made of hydrogen and carbon compounds. The name "hydrocarbon" (one of many names for the resource) reflects its composition. Like coal, petroleum begins with the death and burial of organic materials. Unlike coal, hydrocarbons are mostly derived from small marine animals and phytoplankton. Several steps must first take place, however, before petroleum is "cooked" or mature enough to remove, purify, and use. First, plants and/or animals die and fall into muds deposited in oxygen-poor waters. Burial, compression, and increased temperatures combine to change the loose sediments into layers of sedimentary rocks. Over time, chemical changes take place forcing hydrogen and carbon compounds, originally found in the organisms, to alter into "fossil fuels."

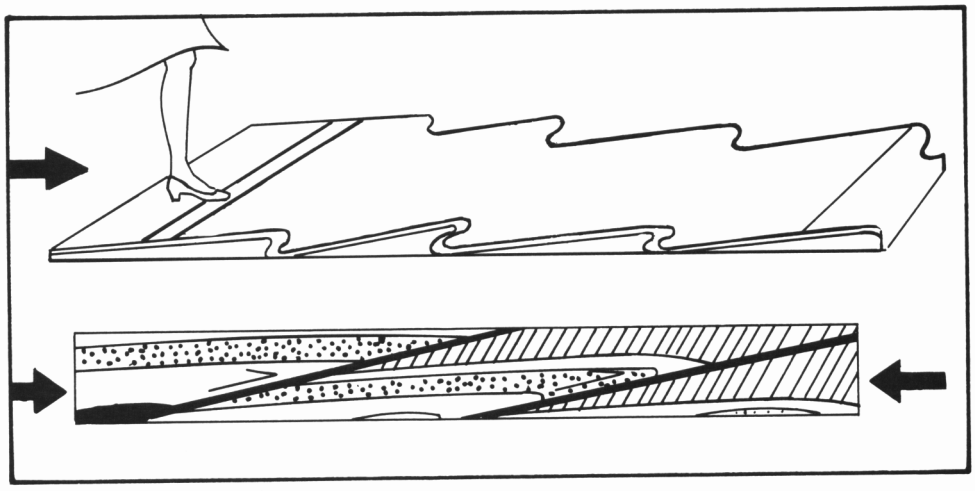


Oil moves to areas of lower pressure by seeping through open spaces created by faulting, breaking, and porosity. Impermeable rocks coupled with structural "traps" like this folded antiform help stop oil's movements.

Like air trapped in a balloon seeking escape into the lower pressures of our atmosphere, petroleum that formed in the carbon-rich "source" beds seeks lower pressures and moves through cracks and spaces in the overlying rocks. Migration continues until equilibrium is reached or an impermeable layer (sediments whose cracks and pore spaces are too tight for the hydrocarbons to enter) is encountered. At this point, the hydrocarbons are trapped and come to rest in "reservoir" or "host" rock. Faults and folds are common traps and are often critical to the evolution of economically feasible oil and gas fields. Faults allow the hydrocarbons to move through broken, fragmented rocks. Folds help concentrate the fuels into underground pools and enable accumulation into large economic deposits or "fields."

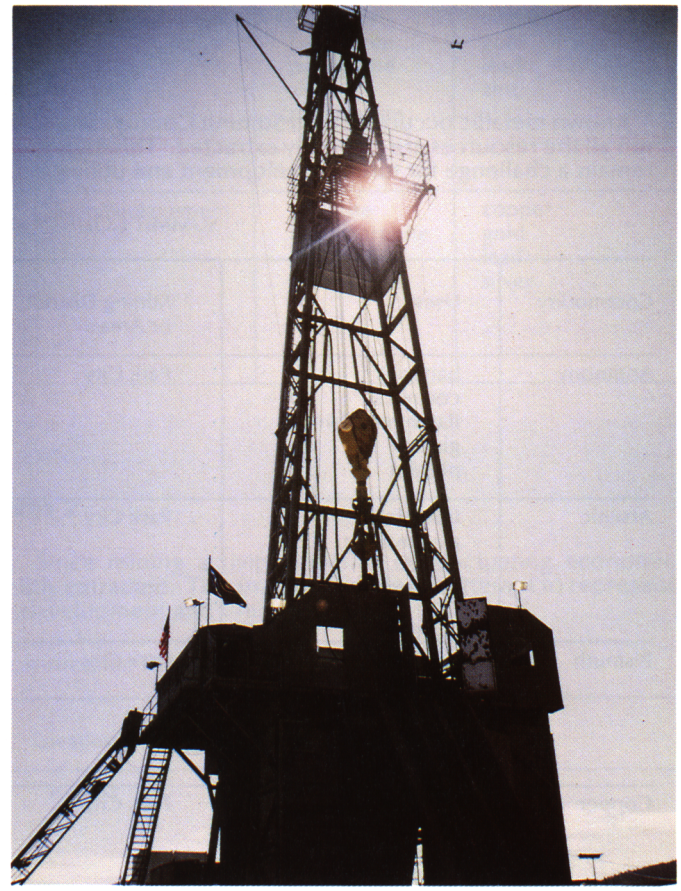
Summit County lies within a large oil and gas province called the overthrust belt. This structural feature extends for thousands of miles and formed as a result of plate tectonic movement. The Utah-Idaho-Wyoming portion of the belt is over 100 miles wide and 200 miles long. The overthrust belt is an area of complexly folded and faulted rocks. Millions of years ago, the Pacific crustal plate collided with the westward-moving North American plate and caused extensive deformation. This collision prompted shearing and eastward thrusting of massive sheets of sediments over neighboring rocks. Deformation in the Summit County portion of the thrust occurred during a 90-million-year period beginning in Jurassic time and ending in early Tertiary time. These events caused porous Mesozoic and Paleozoic host rocks to rest upon petroleum-rich Cretaceous marine shales (source rocks). During the last 60+ million years, petroleum moved upward into spaces in the reservoir rocks and formed the oil fields of today.

In the early 1800s, discovery of oil seeps and springs in southwestern Wyoming encouraged exploration in the area. Activity produced only minor amounts of oil until the 1970s. In 1975, the discovery of the Pineview oil field in Summit County sparked new interest in overthrust belt investigations that ultimately lead to discovery of one of the largest petroleum reservoirs in the western United States.



Thrust faults form by squeezing or compressional forces. Similar to a sliding carpet, the earth's layers "wrinkle" (fold) and break (fault), pushing strata that once sat side by side on top of one another.

Summit County presently has eleven oil and gas fields. The fields and their discovery dates are: Bridger Lake (1966), Pineview (1975), Lodgepole (1977), Elkhorn (1977), Anschutz Ranch (1978), Anschutz Ranch East (1980), Aagard Ranch (1982), Cave Creek (1981), Lodgepole South (1978), Pineview North (1983) and Anschutz/Weber Pool (1985). One hundred and seven wells were active in Summit County in 1988 and the cumulative production for the county (for both producing and non-producing wells) totalled 116,780,225 BBL (barrels) oil and 857,921,869 MSCF (thousand cubic feet) gas and 46,654,088 MSCF water by the end of 1988. The county's fields produce oil and gas from formations ranging in age from Late Cretaceous (around 90 million years ago) to Ordovician (about 440 million years old) and production zones range from 3,000 feet (Tertiary Wanship Formation in the Pineview field) to over 15,000 feet (Lower Cretaceous Dakota Formation in the Bridger Lake field).



Although petroleum exploration has a long history in Summit County, large reserves were not discovered until advanced technology provided better understanding of the subsurface geology as well as the ability to drill to extreme depths.

LIST OF REFERENCES

*Bullock, K.C., 1981, Minerals and mineral localities of Utah: Utah Geological and Mineral Survey Bulletin 117, 177 p.

*Boutwell, J.M., 1912, Geology and ore deposits of the Park City district, Utah: U.S. Geological Survey Professional Paper 77, 231 p.

Division of Oil, Gas, and Mining, 1987, Production report.

Doelling, H.H., and Graham, R.L., 1972, Eastern and northern Utah coal fields: Vernal, Henry Mountains, Sego, La Sal-San Juan, Tabby Mountain, Coalville, Henrys Fork, Goose Creek and Lost Creek: Utah Geological and Mineral Survey Monograph 2, 409 p.

Erickson, A.J., Jr., Phillips, W.R., and Garmoe, W.J., editors, 1968, Guidebook to the geology of Utah, Park City district, Utah: Utah Geological Society, guidebook number 22, 102 p.

*Hintze, L.F., 1988, Geologic history of Utah: Brigham Young University Geology Studies Special Publication 7, 210 p.

Ridge, J.D., editor, 1970, Ore deposits of the United States, 1933-1967: The American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., New York, vol. 2, p. 1103-1126.

Ritzma, H.R., 1981, Thrust belt only the beginning: Utah Geological and Mineral Survey Notes, vol. 15, no. 1, p.1-4.

Stokes, W.L., 1969, Stratigraphy of the Salt Lake region, *in* Mead, LeRoy Jensen, editor, Guidebook of Northern Utah: Utah Geological and Mineral Survey Bulletin 82, p. 37-49.

*Stokes, W.L., 1986, Geology of Utah: Utah Museum of Natural History Occasional Paper 6, 305 p.

Stringham, Bronson, and Cahoon, H.P., 1959, Ceramic red clay near Henefer, Utah: Intermountain Association of Petroleum Geologists, 10th annual field conference, p. 204-206.

*Thompson, G.A., and Buck, F., 1981, Treasure Mountain home, Park City revisited: Dream Garden Press, Salt Lake City, Utah, 226 p.

Utah Geological and Mineral Survey, 1969, Mineral and water resources of Utah: Utah Geological and Mineral Survey Bulletin 73, 275 p.

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

Williams, N.C., Guidebook to the geology of the Wasatch and Uinta Mountains transition area: Intermountain Association of Petroleum Geologists, tenth annual field conference, 235 p.

**Recommended reading*

Table 1

Known metallic occurrences in Summit County. Since mining activity depends on fluctuating economic conditions, not all the resources are currently extracted. This inventory does not attempt to represent unexploited resources that remain a challenge for future development and utilization.

SUMMIT COUNTY METALLIC RESOURCES

Commodity	Uses	Mining District or Area	Occurrence	Ore Minerals	Associated Metals
Antimony	batteries ceramics flame retardant glass plastics	Park City	vein/replacement	bournonite jamesonite pyragyrite stibnite tetrahedrite	copper gold lead silver zinc
Arsenic	insecticides glassmaking wood preservative	Park City	vein/replacement	balydonite mimetite olivenite	copper gold lead silver zinc
Bismuth	ceramics chemicals machine parts paints plastics	Park City	vein/replacement	bismuth	copper gold lead silver zinc
Copper	alloys ammunition coinage construction electrical products electronic products heat exchangers plumbing transportation	Park City	replacement contact meta- morphism	azurite bornite chalcocite chalcopyrite malachite tetrahedrite	lead silver zinc
Gold	currency dentistry electronics jewelry ornament	Park City/ Woodland area	replacement	calaverite gold	lead silver zinc
Iron	ocher pig iron steel	Park City/ Uinta Mountains	replacement vein/replacement	garnet hematite limonite magnetite pyrite siderite	copper lead silver tungsten
Lead	batteries construction electrical products gas additive glass paint	Park City/ Woodland area	vein/replacement	anglesite cerussite galena jamesonite	copper gold silver zinc
Manganese	construction batteries machinery pig iron steel alloys transportation	Park City/ Beaver Canyon Coalville area	vein	manganite psilomelane pyrolusite rhodochrosite rhodonite	copper gold iron lead silver zinc

Silver	alloys dentistry electrical products electronics jewelry photography sterlingware	Park City/ Kamas area	vein/replacement	argentite cerargyrite pyrargyrite silver tetrahedrite	copper gold lead zinc
Zinc	alloys brass construction electrical products machinery photocopying pigments	Park City/ Kamas area	vein/replacement	goslarite hemimorphite sphalerite tetrahedrite	copper gold lead silver

Table 2

Known non-metallic occurrences in Summit County. Since mining activity depends on fluctuating economic conditions, not all of the resources listed below are currently extracted. This inventory does not attempt to represent unexploited resources that remain a challenge for future development and utilization.

Summit County Non-metallic Resources

Commodity	Uses	Location	Occurrence
Barite	chemicals drilling glass paints rubber	Park City	vein/replacement
Clays bloating clay (see bentonite shale)	drilling mud laundry compounds lining water structures	Coalville area	hydrothermal sedimentary weathering
common clay	bricks ceramics light-weight aggregate medicines tiles	Coalville area Henefer area	
montmorillonite	drilling mud lining water structures	Park City	
Fluorspar	hydrofluoric acid flux in steel manufacturing glass fluorine plastics refrigerants solvents electrical industry	Park City/ Uinta Mountains	replacement sedimentary
Gemstones agatized coral jasperized chert jasperized horn corals	ornamental curiosity	 Woodland area Woodland area	 fossils/replacement sedimentary fossils/replacement
Phosphate Rock	animal feed supplement chemicals fertilizer	Franson Canyon Uinta Mountains	sedimentary

Salt	animal feed supplement food ice control on roads water softeners	Preuss Sandstone in northwestern Summit County	evaporite
Sand and Gravel	aggregate for concrete construction fill filtration railroad ballast winter road safety	Henefer area Hoytsville area Peoa area Wanship area	glacial, lake, and stream sedimentary deposits
Shale bloating clay	light-weight aggregate	Wanship area	sedimentary
Stone crushed stone	concrete aggregate construction railroad ballast riprap	Henefer area	
dimension stone	construction monuments	Park City area Snyderville area Weber Valley area	sedimentary
ornamental stone	decorative displays fireplaces garden walls	Park City area Snyderville area	sedimentary
Sulfur	chemical industry insecticides paper industry sulfuric acid	Coalville area	geothermal springs

Table 3

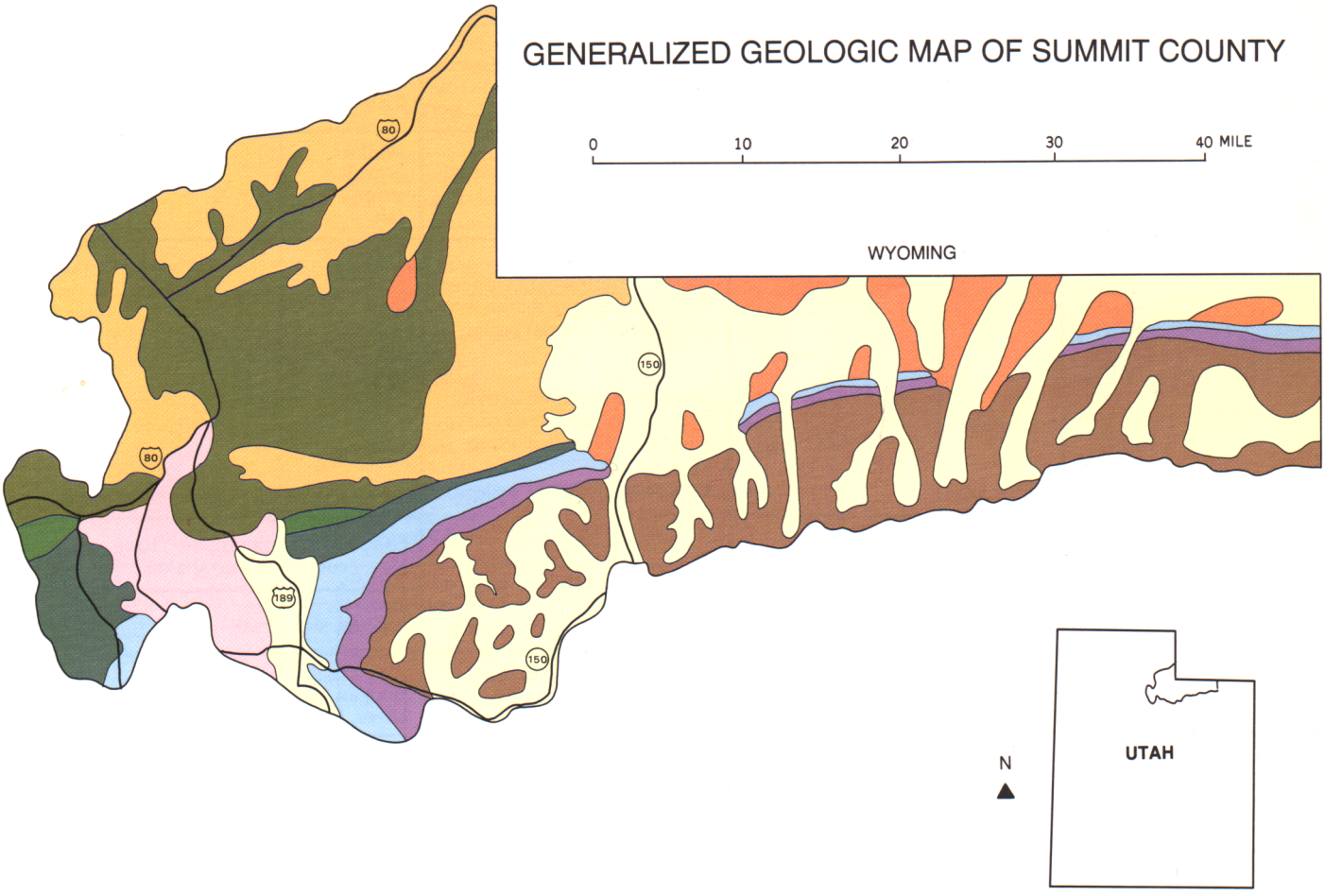
Known energy occurrences in Summit County. Since mining and drilling activity depends on fluctuating economic conditions, not all of the resources listed below are currently extracted. This inventory does not attempt to represent unexploited resources that remain a challenge for future development and utilization.

Summit County Energy Resources

Commodity	Uses	Location	Occurrence
Coal	fuels industrial products	Coalville Henrys Fork	subbituminous bituminous
Geothermal	electricity space heating water heating	Snyderville area	
Oil & Gas	asphalt fuels plastics solvents waxes	Oil & Gas Fields: Aagard Ranch Anschutz Ranch Anschutz Ranch East Anschutz/Weber Pool Bridger Lake Cave Creek Elkhorn Ridge Lodgepole Pineview Pineview North	folded/faulted Mesozoic and Paleozoic sediments
Uranium	nuclear fuels nuclear weapons radioisotopes x-ray targets	Uinta Mountains	sedimentary

GENERALIZED GEOLOGIC TIME SCALE WITH SELECTED RESOURCES

Era	Millions of years ago	Period	Significant Geologic Events	Selected Economic Commodities
Cenozoic		Quaternary	Glaciation Basin and Range extension continues.	sand gravel stone salt
	1.6	Tertiary	5 North America experiences Basin and Range extension. High-angle normal faults form. 25 Increased volcanic activity caused by melting of the subducted Farallon Plate 40 Laramide Orogeny	lead silver zinc gold copper stone clay
	66.4	Cretaceous	80 Sevier Orogeny Thrust faults 150	coal, oil, gas, dimension stone clay, crushed stone, shale
Mesozoic	144	Jurassic		oil, gas, stone, salt
	208	Triassic		oil, gas, stone silver, lead, zinc
Paleozoic	245	Permian		oil, gas phosphate silver lead, zinc
	296	Pennsylvanian		oil, gas phosphate silver, lead, zinc
	320	Mississippian		silver, gold lead, zinc copper, phosphate oil, gas
	360	Devonian		oil gas
	408	Silurian		oil gas
	438	Ordovician		oil gas
	505	Cambrian	550 Unconformity Rocks from this time span are not found in Summit County. 800	stone
	570	Precambrian		



Quaternary

Tertiary Volcanic Rocks

Tertiary Sedimentary Rocks
(25 million years old and younger)

Tertiary Sedimentary Rocks
(older than 25 million years)

Cretaceous

Jurassic

Triassic

Pennsylvanian-Permian

Mississippian

Precambrian