GEOLOGIC RESOURCES

of

San Juan County

UTAH

BOOKLET DESIGN: PATTI F. MAGANN

This booklet is one of a series produced by the Utah Geological Survey's Information Geologists. Its purpose is to initiate public awareness of Utah's unique geologic formations and resources, thereby invoking appreciation for the state's wealth of diverse beauty and economic strengths.
The text includes sections on geologic background, resources, energy, metals and non-metals, scenery, and references. Included are maps and diagrams, as well as informative tables highlighting resources.

DEPARTMENT OF NATURAL RESOURCES
Utah Geological Survey
PUBLIC INFORMATION SERIES 14 1992

Credits

Text by Sandra N. Eldredge. Photos by author unless otherwise credited. Diagram assistance and mineral resource tables by Christine M. Wilkerson. Illustrations by James W. Parker and Lori J. Douglas. Special thanks go to Christine M. Wilkerson for her assistance in assembling this brochure, and to the individuals who provided valuable reviews. Cover and booklet design by Patti F. MaGann. Cover photo: The Colorado River from Dead Horse Point overlook in San Juan County. View is to the south into Canyonlands National Park. Courtesy Utah Travel Council. Background photo: Upheaval Dome, Canyonlands National Park, courtesy of William F. Case.

Geologic Resources of San Juan County

by Sandra N. Eldredge

Purpose

This brochure introduces San Juan County's geology and geologic resources. Understanding earth's dynamic forces that form the resources helps us visualize the complexity and uniqueness of each naturally occurring deposit. Learning about the role resources play in our economy and quality of life helps us realize how dependent we are on them; yet these resources exist in limited supply. This awareness necessitates knowledgeable and prudent resource management.

Description

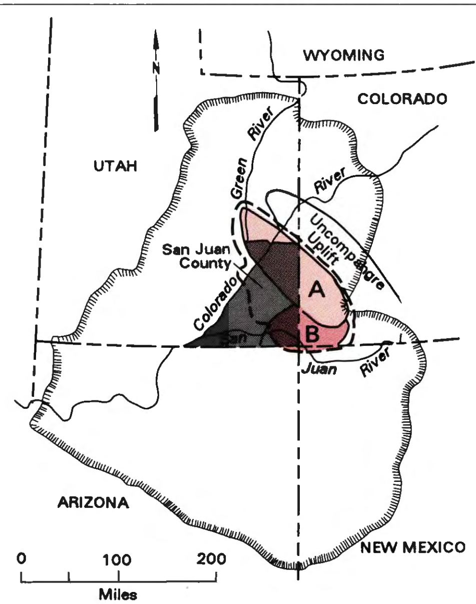
The geologic resources are divided into four categories: (1) energy, (2) metallic, (3) non-metallic, and (4) scenic. The brochure discusses the geologic forces that form these resources, the development and historical use of the resources, and current production. Resources that have been the most prominent in San Juan County's economy and history are selected for detailed discussion. Tables, diagrams, and maps are provided as reading aids. The geologic column on page 4, "Geologic Events and Resources of San Juan County," can be used as a summary reference and to equate rock formation names with geologic time periods. Footnotes define selected terminology.

Introduction

San Juan County is known for its remote setting, panoramic scenery, and rich deposits of oil, gas, and uranium. As the largest of Utah's 29 counties, San Juan County encompasses an area of 7,707 square miles, of which about one-third is Navajo Indian Reservation. Located in the heart of the Colorado Plateau[1], the area is known by names such as the "canyonlands region" or "red-rock country." The land is characterized by deep canyons cut by the Colorado River and its tributaries, broad mesas, buttes, hogback ridges, sage plains, and isolated mountains. Mineral extraction and tourism, two significant job providers in San Juan County, tie geology to the county's financial base.

While geologic resources have been in the making for hundreds of millions of years, it is only in the last several thousand years that people have utilized them. The Anasazi Indians and their predecessors, who lived here more than 10,000 years ago until about A.D. 1300, used natural resources, leaving behind renowned ruins, rock-art panels, and artifacts that make this area an archaeologist's mecca. The most intense resource use, however, began just over 100 years ago when prospectors and pioneers arrived.

Pioneer settlers of Bluff (the first town established in San Juan County) arrived in 1880 and quarried local stone to construct many beautiful buildings, some of which are still standing. At the same time, copper, gold, and silver attracted prospectors to this region. In the late 1890s, uranium, vanadium, and radium deposits were discovered; uranium became especially important with the advent of the atomic age in the 1940s.



Outline of the Colorado Plateau

– – – Boundary of the Paradox basin

A Paradox fold and fault belt, subprovince of the Paradox basin

B Blanding basin, subprovince of the Paradox basin

[1]*The Colorado Plateau is a high tableland dissected by canyons, where rock layers remain mostly flat over wide areas.*

Oil and gas production has replaced uranium as the busiest extractive industry in San Juan County. The first well was drilled in 1907, but it was not until the 1956 discovery of the Greater Aneth field in the southeastern part of the county that an oil boom occurred. The 1990s are seeing a resurgence of exploration as improved technology pinpoints smaller fields that were bypassed earlier.

Another growing industry in the county is tourism. The unique rock landscapes in and around national and state parks, monuments, recreational and scenic areas attract multitudes of tourists and recreationists. The grand rivers that carve through the red rock and the isolated mountains that tower above the stark expanse provide additional scenic and recreational opportunities. Cultural and archaeological resources are found in their natural setting here, luring professional and amateur archaeologists alike.

The diversity of resources and land uses is evident: oil pumps and rigs dot the skyline amidst hogans, livestock, and uranium mines; and people explore the land, floating down the intriguing canyon rivers and visiting the parks. Increased competition for land uses demands informed, long-term resource management.

Geologic Background

Natural resources are formed by geologic events that have taken place throughout earth's history. For hundreds of millions of years, the area that is now San Juan County lay underneath vast shallow oceans. The marine waters deposited carbonate-rich sediments that eventually became limestones and dolomites. Approximately 320 million years ago, the Uncompahgre uplift (a mountainous-like island) began rising northeast of San Juan County. Along the southwest flank of the uplift, a large depression developed into what we now call the Paradox basin–a 20,000 square mile area that contained a restricted arm of the sea. Repeatedly, the sea water filled the basin, and each time retreated to cumulatively deposit thousands of feet of salt and other saline deposits. The Paradox basin, defined today by the area underlain by these salt deposits, covers southeastern Utah, including the northeastern two-thirds of San Juan County.

The sea retreated 245 million years ago, and drier climatic conditions transformed the landscape into immense sandy deserts. At times, a wetter environment produced rivers and freshwater lakes that were home to dinosaurs and other prehistoric animals. The widespread sand dune deserts were changed to the massive, gold, orange, and red-colored sandstone cliffs and petrified sand dunes we see today. Sediments deposited in rivers, lakes, and tidal flats resulted in various colors of shales, siltstones, and sandstones. These multicolored rocks are now renowned striking features of southeast Utah's canyon country.

Geologic Events and Resources of San Juan County

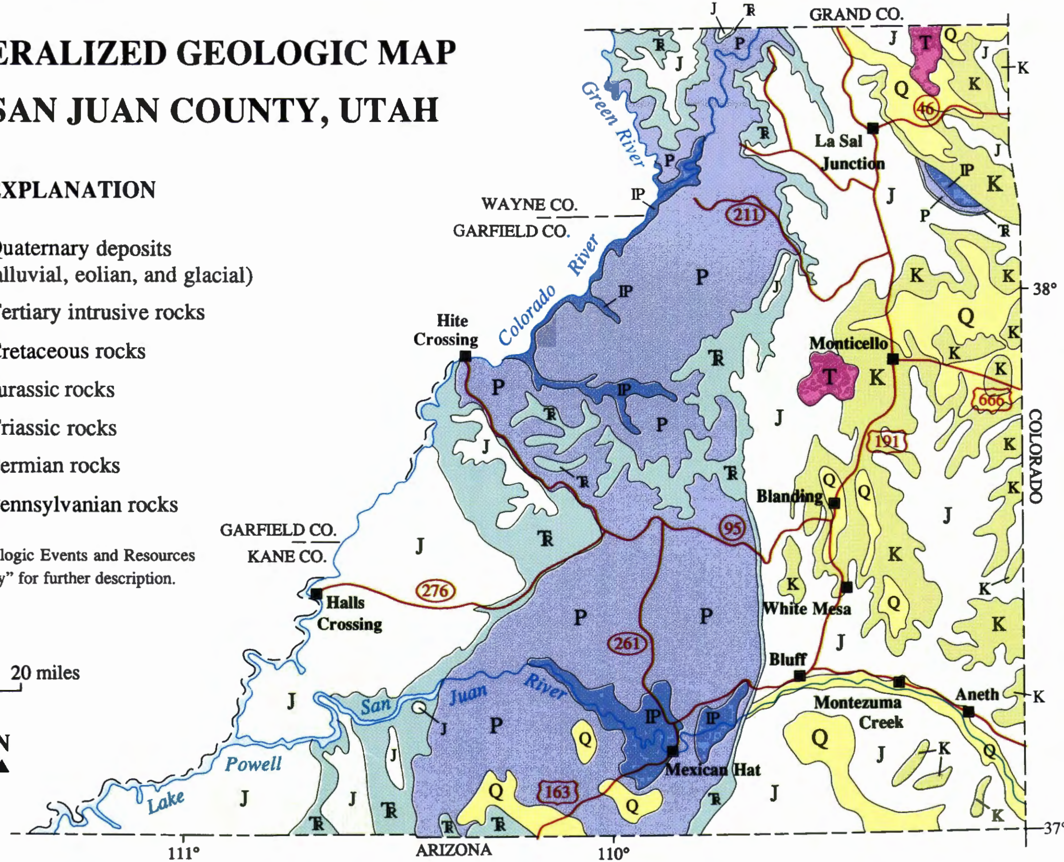
PERIOD Millions of Years Ago	GEOLOGIC EVENTS	GEOLOGIC FORMATIONS (Fm)	SELECTED RESOURCES
Quaternary	Erosion Surficial deposits Glaciation in La Sal Mtns. Dissolution of salt anticlines Colorado River and tributaries cut down into rising Colorado Plateau	Alluvial, eolian, and glacial deposits	Sand and gravel Placer gold
1.6 Tertiary	Colorado Plateau uplift La Sal, Abajo, and Navajo Mt. intrusions Diatremes (volcanic vents)	Igneous rock	Copper Gold Silver Gemstones
66.4 Cretaceous	Inland sea deposits sandstones and shales Peat (coal) forms in bordering swamps	Mancos Shale Dakota Sandstone Burro Canyon Fm	Coal Clay Copper
144 Jurassic	Semi-arid conditions result in a large desert where sand dunes accumulate, interspersed with intermittent streams and playa-lake complexes where dinosaurs roam Continued salt movement	Morrison Fm Wanakah Fm Entrada Sandstone Carmel Fm Navajo Sandstone Kayenta Fm Wingate Sandstone	Dinosaur bones Dinosaur tracks Uranium Vanadium Petrified wood Zeolites Dimension stone RAINBOW BRIDGE DEAD HORSE POINT CANYONLANDS NATIONAL PARK
208 Triassic	Silts and muds are carried down by rivers from the Uncompahgre uplift and accumulate as thick flood-plain, delta, and tidal-flat deposits Sea retreats Continued salt movement	Chinle Fm Moenkopi Fm	Major uranium Copper Clay Petrified wood CANYONLANDS NATIONAL PARK
245 Permian	Sea deposits sandstones and shales Uncompahgre uplift continues to rise Continued salt movement	Cutler Group: White Rim Sandstone and De Chelly Sandstone Organ Rock Fm Cedar Mesa Sandstone Halgaito Fm and Elephant Canyon Fm	MONUMENT VALLEY NATURAL BRIDGES VALLEY OF THE GODS CANYONLANDS NATIONAL PARK Dimension stone Uranium Minor copper Oil and gas
286 Pennsylvanian	Beginning of salt anticline movement Uncompaghre uplift rises, as the Paradox basin subsides and is submerged under an arm of the ocean. Thick evaporites interbedded with organic-rich shales are deposited in the basin, while limestones and dolomites accumulate on the basin shelf to the southwest	Honaker Trail Fm Paradox Fm Pinkerton Trail Fm Molas Fm	Salt Potash Gypsum Major oil and gas
320 Mississippian	Seas deposit limestones and dolomites	Leadville Limestone	Major oil and gas
360 Devonian	Seas deposit limestones and dolomites	Ouray Limestone Elbert Fm Aneth Fm	Oil and gas
408 Silurian	Non-deposition or erosion		
438 Ordovician	Non-deposition or erosion		
505 Cambrian	Seas deposit sandstones, shales, limestones, and dolomites	(not exposed at surface)	

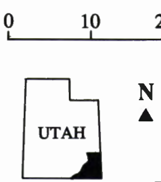
GENERALIZED GEOLOGIC MAP OF SAN JUAN COUNTY, UTAH

EXPLANATION

Q	Quaternary deposits (alluvial, eolian, and glacial)
T	Tertiary intrusive rocks
K	Cretaceous rocks
J	Jurassic rocks
TR	Triassic rocks
P	Permian rocks
IP	Pennsylvanian rocks

See column, "Geologic Events and Resources of San Juan County" for further description.





San Juan County was last inundated by marine water 95 to 80 million years ago. During this time, an inland sea existed in a warm, moist climate. Peat formed in the bordering swamps and marshes, and later evolved into coal.

Less than 30 million years ago, the mountainous areas in San Juan County were created: the La Sal and Abajo Mountains north of the San Juan River, and Navajo Mountain south of the river. In these areas, melted rock (magma) deep beneath the surface was intruded into the overlying rock. As the magma moved upward, it hardened into domelike intrusions, and raised the rock layers above it. At Navajo Mountain, the overlying rocks are still present. In contrast, the rocks previously covering the La Sal and Abajo intrusions were eroded, leaving the intruded granitic rocks dramatically exposed above the landscape. Metal deposits, such as gold, copper, and silver are associated with these intrusions.

About 15 million years ago, the Colorado Plateau began to rise thousands of feet. In the last 1.5 million years, the Colorado River and its tributaries have carved precipitous canyons into this elevated land mass. Erosion continues to sculpt intricate canyons and unique landforms such as arches, natural bridges, fins, spires, and monuments.

Resources

San Juan County's geologic environments yield energy, metallic, non-metallic, and scenic resources, all of which play a significant role in the county and state economies. San Juan County is the leading oil and gas producer in Utah, and at times the county has been a leading producer of uranium. Yields of other metals and non-metals have been on a smaller scale. The fascinating canyon and red-rock scenery has generated a significant tourism economy.

For a complete listing of the mineral resources existing in San Juan County, refer to tables 1, 2, and 3 in the back of the brochure.

Energy

Energy, the capacity to do work, exists in various forms including manual, mechanical, chemical, heat, gravitational, and electrical. As civilizations grew in size and sophistication, more efficient forms of energy evolved: gas and electric heat in our homes replaced wood and coal; petroleum-powered transportation replaced the horse and buggy; and electric freezers and refrigerators replaced root cellars for food storage.

Oil, natural gas, and coal are the main energy resources found in San Juan County (see table 1). Oil and natural gas are produced in large quantities in the county, whereas coal exists as a potential commodity. Coal occurs in the Cretaceous-age Dakota Sandstone found in the eastern part of the county. The coal beds are thin, discontinuous, and of relatively poor quality. Due to oil's economic significance in the county, it is discussed below (many of the descriptions apply to gas as well).

Oil (petroleum)

- ***What is oil?*** Oil, also called petroleum, originates from the remains of tiny plants and animals (organic matter). When the organic matter is deeply buried under other sediments over time, heat and pressure transform the material into kerogen. As the transformation continues, kerogen eventually generates and expels oil.

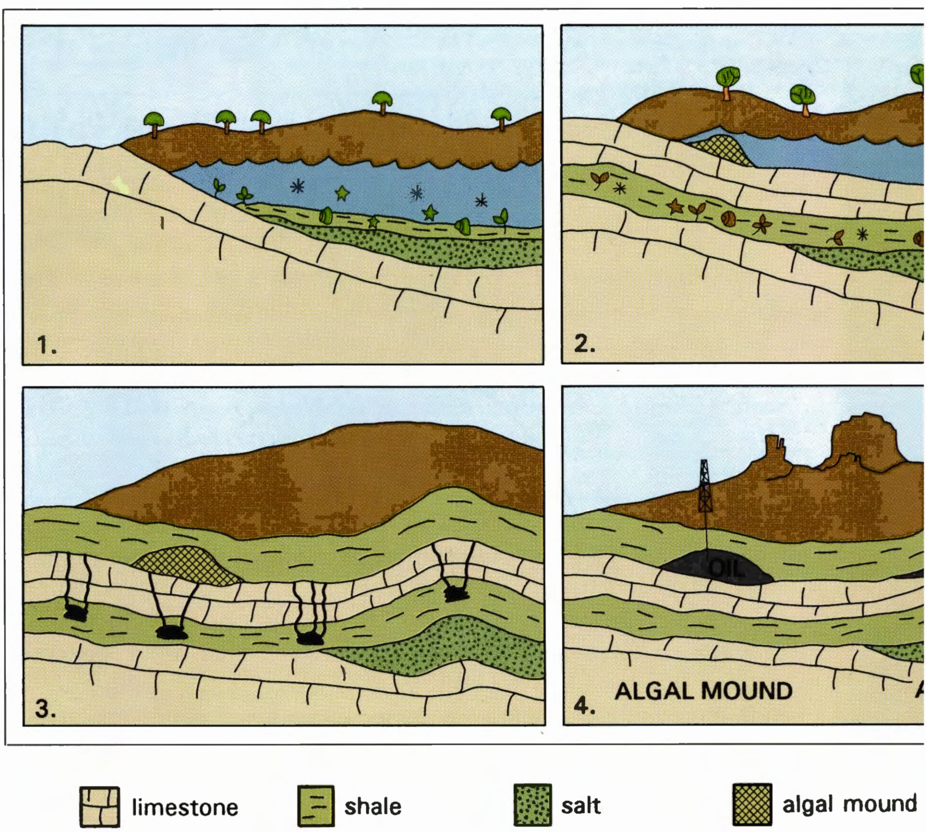
- ***What is oil used for?*** We recognize oil as a major source of energy used for transportation, heating, and electricity. Oil is also used in a variety of other applications; the thousands of products derived from oil include lubricating oils, greases, waxes, asphalts, plastics, detergents, paints and varnishes, photographic films, medicines, synthetic fibers, and fertilizers. Native Americans used oil to waterproof canoes and make medicines.

- ***Why does oil occur in San Juan County?*** Four conditions are needed for oil to form and accumulate: (1) preservation of dead organic matter in oxygen-depleted environments that are subsequently incorporated into sediments and deeply buried so that heat, pressure, and time can convert the matter into kerogen (source rock); (2) underground movement of the oil to a storage area consisting of porous and permeable rocks[2], generally sandstone, limestone, and dolomite (reservoir rock); (3) a trapping mechanism that concentrates oil into economic quantities and prevents the oil from leaking out of the reservoir rock (trap); and (4) that all of the above occur in an uniquely timed sequence of events.

[2]*Porous and permeable rocks are perforated with networks of holes like a sponge, through which water, oil, and gas can travel.*

Commercial quantities of oil are found in the Paradox basin portion of San Juan County. When the sea covered the basin, the remains of tiny plants and animals accumulated with mud on the ocean floor. Quiet, oxygen-depleted waters of the basin enabled preservation of the organic matter. The organic-rich sediments were buried by thousands of feet of sand, salt, and mud over hundreds of millions of years. This burial increased heat and pressure, and in time transformed the organic material into petroleum. Burial also changed sediments into hard rock: the organic-rich mud became black shale and carbonate sediments hardened into limestone.

Two subprovinces of the Paradox basin, the Blanding basin to the south, and the Paradox fold and fault belt to the north, have different types of petroleum traps. Oil in the Blanding basin is mostly located in stratigraphic traps[3], such as algal mounds[4]. Structural traps[5], such as anticlines[6] and faults[7], provide the mechanism for accumulating oil in the fold and fault belt.



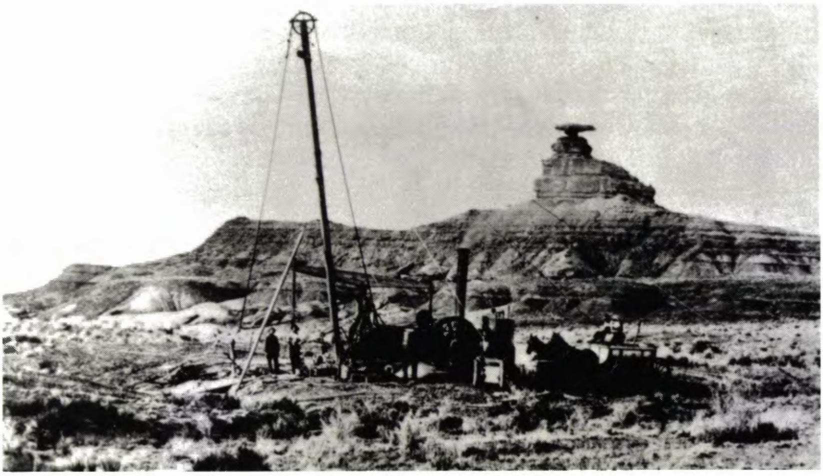
The major oil-producing formation in the Paradox basin is the Pennsylvanian-age Paradox Formation. The Paradox Formation consists of salt with interbedded shale, limestone, and dolomite. The salts and shales were deposited in a cyclic manner at least 29 times corresponding with sea-level fluctuations; each influx of water resulted in deposition of a shale layer, followed by a retreat of the sea that created increased salinity and resulted in deposition of salt. On the margins of the basin, especially to the southwest, reefs and algal mounds grew in the shallow warm waters. Reef features are often preserved in limestones and dolomites. Many of the limestone and dolomite beds in the Paradox Formation are petroleum reservoirs, while the organic-rich shales are generally thought to be the source rock.

Exploration history and current trends

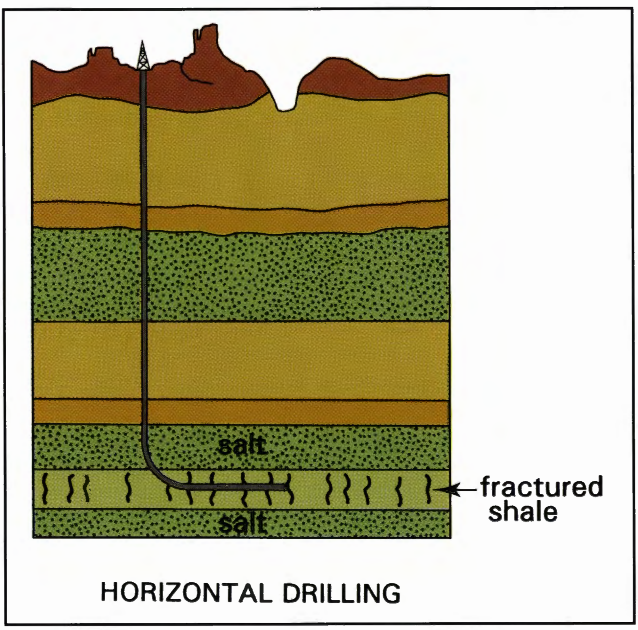
Oil seeps along the San Juan River led to the 1907 discovery of the Mexican Hat field. Other fields were located in following years, but it wasn't until the discovery of the Greater Aneth field (one of the world's largest Pennsylvanian-age oil accumulations) in 1956, that a large exploration program throughout the basin followed. In 1960, the Lisbon field was discovered in the Paradox fold and fault belt portion of San Juan County. Oil and gas production in the Lisbon field is from Mississippian-, Devonian-, and Pennsylvanian-age formations. The Lisbon field is the largest producer from the Mississippian rocks in the Paradox basin, and it is also the largest producer in the fold and fault belt.

A simplified view through time of the origin of oil, and the relationship between source rocks, reservoir rocks, and traps. (1) Prehistoric ocean life flourishes hundreds of millions of years ago. (2) Ocean life dies and is buried in mud, which eventually hardens into shale (source rock). In shallow water, carbonate sediments are deposited and algal mounds grow; they eventually harden into limestone. (3) The sea has retreated. An anticline forms due to compression within the earth's crust. Heat and pressure, created by deep burial over time, alter the former ocean life into oil. The oil then migrates upwards, seeking lower pressure, to the porous and permeable limestone and algal mound (reservoir rocks). The impermeable shale above prevents the oil from moving further. (4) On the left side of the diagram, oil is trapped and accumulates in the algal mound (stratigraphic trap). On the right side, oil is trapped at the crest of the anticline (structural trap). Because water is present in the reservoir rocks, the lighter oil migrates above the water to the top of the traps. Note–in the Paradox basin there are many cyclic layers of salts, shales, limestones, and dolomites.

[3]Stratigraphic traps – oil and gas reservoirs that form as a result of changes in rock type; impermeable rock, when laterally or vertically bordering porous and permeable reservoir rock, acts as a seal to trap the petroleum in the reservoir rock. [4]Algal mounds (algal reef mounds) – reef-like structures that formed in warm shallow seas, where algae and other organic debris accumulated like a modern-day coral reef. These mounds can measure several miles in diameter, and often form porous and permeable limestones and dolomites. Algal mounds are found in the Pennsylvanian-age Paradox Formation and older formations. [5]Structural traps– oil and gas reservoirs that form when the reservoir rock is deformed by folding or faulting. [6]Anticline – a fold in the rocks in which sides slope downward and away from the crest; an upfold (see diagram). [7] Fault – a break in the rocks along which movement has taken place.



Drilling for oil near Mexican Hat, early 1900s. Photo courtesy Utah Historical Society.



Oil remains in some of the shale zones when bounded by impermeable salts. Oil can then be produced from fractures in these shales by drilling horizontally. It is difficult to find enough fractures to produce oil with a traditional vertical well, but by drilling horizontally in the shale zone the chances of encountering the fractures are greatly increased.

Two main exploratory trends in the 1990s are in algal reef mounds and horizontal drilling in shale zones. Seven new fields discovered in San Juan County in 1990 were all algal mound finds (see previous algal mound discussion). Most recently, the new technology of horizontal drilling is being used to explore for oil in the fractured "Cane Creek" shale of the Paradox Formation. Currently, horizontal wells exist near the border of Grand County and San Juan County, in the vicinity of Dead Horse Point State Park and Canyonlands National Park. Additional wells are planned for the near future.

The Paradox basin is one of the premier oil and gas producing areas in the nation. So far, most production has been from the stratigraphically controlled Pennsylvanian-age reservoirs in the southern portion (Blanding basin). The algal mounds in Blanding basin should continue to be the focus of very active exploration, especially with the application of new geophysical techniques to help locate small but rich oil accumulations that had been previously overlooked. And the "Cane Creek" reservoir (as well as other potential shale units in the Paradox Formation) throughout the basin could be a prolific oil producer if horizontal drilling proves economical.

EXAMPLES OF OIL AND GAS PRODUCTION IN SAN JUAN COUNTY

LOCATION	1990	CUMULATIVE[1]
GREATER ANETH FIELD	5,669,186 BBLS[2] OIL 3,179,473 MCF[3] GAS	>270,400,000 BBLS OIL >244,100,000 MCF GAS
Discovered 1956. One of world's largest Pennsylvanian oil accumulations. Largest oil producer in Utah. Considerable recoverable reserves remaining.		
LISBON FIELD	415,105 BBLS OIL 21,635,443 MCF GAS	> 49,400,000 BBLS OIL > 43,400,000 MCF GAS
Discovered 1960. Largest producer in the Paradox fold and fault belt. Largest Mississippian find in the Paradox basin. Third largest gas producer in Utah, 1990.		
SAN JUAN COUNTY	7,743,073 BBLS OIL 31,504,484 MCF GAS	>361,000,000 BBLS OIL >914,800,000 MCF GAS
In 1990, San Juan County produced 28% of Utah's oil and 10% of Utah's gas. San Juan County has produced more oil than any other county in Utah.		

[1] *Cumulative production through 1990 for Greater Aneth and Lisbon fields, and through March, 1991 for San Juan County (Utah Division of Oil, Gas and Mining, 1991 and Staley, 1991).*

[2] *BBLS = barrels*

[3] *MCF = thousand cubic feet*

Metals

Metals are naturally occurring substances that usually have a metallic luster and ordinarily are good conductors of heat and electricity. Metallic minerals are usually contained in rock and are of little use until extracted and refined.

Currently, very little mining activity occurs in San Juan County. However, there has been a productive past, and with improved market conditions the future holds potential for additional exploration. The radioactive uranium, vanadium, and radium metals and the non-radioactive gold, copper, silver, and other associated metals have been mined in the county (see table 2 for a complete list).

The non-radioactive metals often occur in association with the igneous intrusions of the Abajo and La Sal Mountains. In the late 1800s, prospectors reported gold discoveries in the mountains, and along the Colorado and San Juan Rivers. Placer gold discovered along the San Juan River in the 1890s instigated a gold rush when over 1,000 prospectors staked claims and established several gold camps. To reach claims in the deepest part of the river canyon, the famous Honaker trail was built. Unfortunately, the first horse to be led down the trail fell to the canyon bottom. River runners hike this trail today and marvel at the prospectors' determination. The gold rush was short-lived and left many prospectors empty-handed as the placer gold in the San Juan River is very fine and difficult to recover. Most gold panning and sluicing occurred below the mouth of Montezuma Creek to the confluence with the Colorado River. The more extensive workings on the Colorado River were between the present location of Hite to the Utah/Arizona state line.

Gold mining along the San Juan River, 1894 . Five dollars per day was paid to each man working this claim. Photo courtesy Utah Historical Society.

San Juan County prospectors use the familiar gold pan today in the La Sal Mountains.

Copper and copper-silver ores were mined primarily in the La Sal Mountains in the late 1800s, and later in the Abajo Mountains, Lisbon Valley, and the White Canyon mining district. Copper was often extracted from copper-bearing uranium ores. Silver, found in association with the copper and uranium ores in the county, has been extracted in small amounts.

Uranium-vanadium ores, discovered in the late 1890s, were originally mined in small amounts. However, with the interest in atomic weaponry in the 1940s, San Juan County became Utah's largest uranium producer. Uranium has been the leading metal produced in San Juan County. Due to uranium's economic significance in the county, it is highlighted below.

Uranium

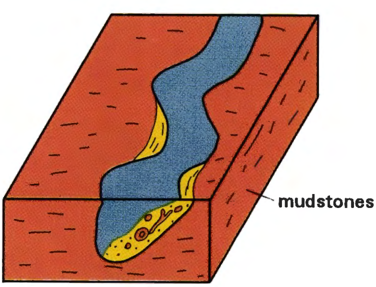
- ***What is uranium?*** Uranium, a silvery-white radioactive metal, is usually considered an energy resource since it can produce huge quantities of heat as it undergoes radioactive decay. The metal is found bonded to other elements in minerals.
- ***What is uranium used for?*** Uranium is used in nuclear fuels, medicine, and for scientific research. Native people used uranium minerals, with their variety of colors including yellow, blue, black, and green, for pigments. During and after World War II, uranium was used for developing nuclear weapons. Now it is used principally as a fuel for nuclear reactors.

During 1989, more than 20 percent of the electricity generated in the United States came from nuclear power. Although nuclear power plants are economically beneficial (for example, one pound of uranium can produce as much energy as about 14,000 pounds of coal), there are public fears about the safety of nuclear plants, as well as unresolved issues regarding disposal of nuclear waste generated at plants.

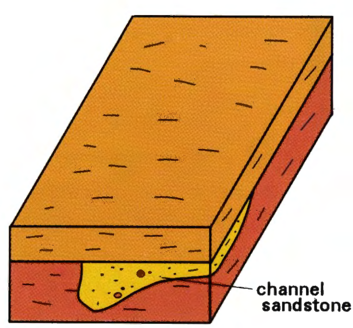
Why does uranium occur in San Juan County? Uranium exists in the earth's crust as one of its numerous elements. Throughout earth's history, uranium has been leached by surface and ground waters, and then concentrated in certain geologic environments. In the Colorado Plateau, where most of Utah's uranium is found, the most common uranium-bearing rock unit is sandstone of the Chinle and Morrison Formations (Triassic and Jurassic age, respectively). The sandstone beds were deposited in ancient stream courses that flowed over broad plains. The ore minerals, which were introduced millions of years later by uranium-charged waters, occupy pore spaces between grains of sand in the sandstones and replace the carbon in logs and other fossil plant debris. Typically, the mineralized sandstones are bounded by mudstones.

Exploration history and current trends. Uranium mining activity fluctuates with demands for radium, vanadium, and uranium, and the history is quite intriguing. In the late 1800s, miners looking for their fortune in the Colorado Plateau found petrified logs containing yellow, blue, black, and green minerals. The logs were assayed for valuable metals, but only traces of gold, silver, and other important metals were found. In the late 1890s, the ore was discovered to contain uranium and vanadium in a mineral combination called carnotite.

The Role Ancient Stream Channels Play in the Location of Uranium Deposits



200 million years ago, stream channels cut into pre-existing mudstone and siltstone. The channels filled with sands, pebbles, cobbles, logs and other plant debris (the latter tends to accumulate on the inside bends of meanders).



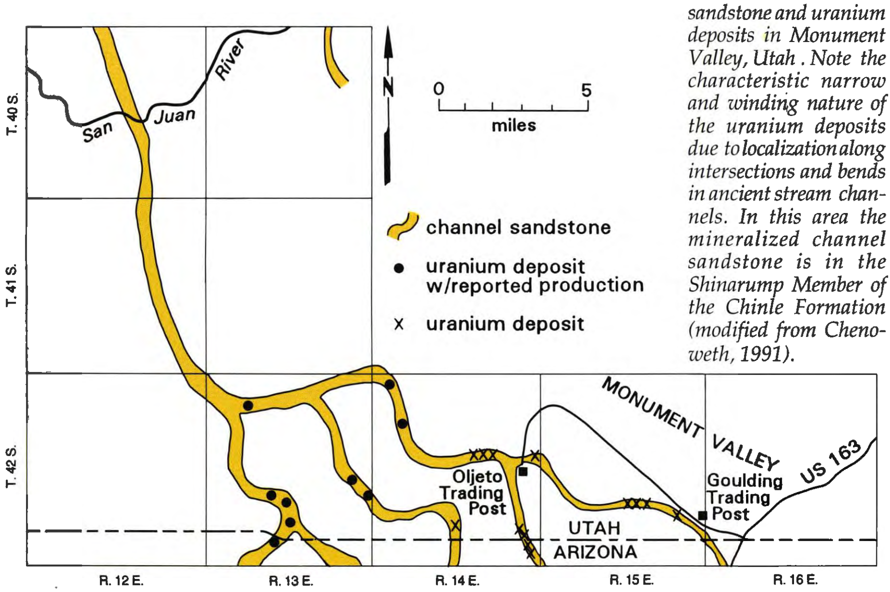
Channel deposits, which become predominantly coarse-grained sandstone, are later buried by floodplain mudstone. Ground water leaches uranium from the surrounding mudstone and concentrates uranium in the channel sandstone around carbonized vegetal matter.

At first, carnotite was mined for its radium content. Radium was used in the treatment of cancer following the Curies' discovery of this highly radioactive element. Many miners believed in radium cures for certain ailments; some wore sacks of uranium around their necks to cure cancer of the throat or drank bottles of water containing uranium chunks to soothe rheumatism.

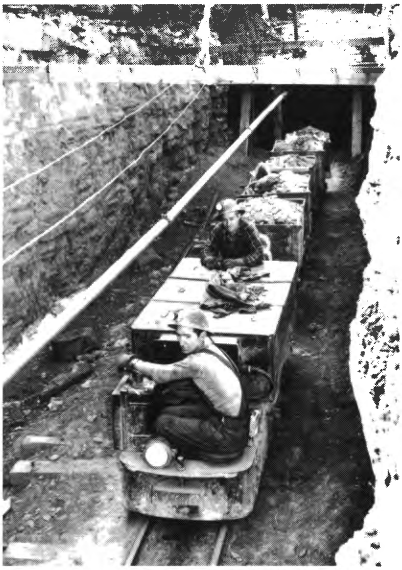
When foreign markets supplied better radium sources in the 1920s, carnotite was mined for the vanadium, which was primarily used as an alloy with steel.

During World War II, uranium became the more valuable mineral for use in atomic weaponry. For the super-secret wartime Manhattan Project, uranium was purchased from the vanadium mills at Monticello. Due to the secrecy of the project, initially miners were not told that uranium was being recovered from their carnotite ore. When the U.S. Atomic Energy Commission (AEC) started procuring uranium in 1948, many areas in San Juan County were mined for uranium (see Geologic Resources Map). Uranium mills operated at Hite (mouth of White Canyon), on the Navajo Indian Reservation near Mexican Hat, and in Monticello.

Uranium production decreased in the early 1960s and did not pick up again until commercial nuclear-power production became feasible after 1965. However, the 1980s saw a reduced demand for uranium due to public fears that nuclear power plants might be unsafe, and the availability of cheaper sources of uranium from foreign markets.



Ancient channel sandstone and uranium deposits in Monument Valley, Utah. Note the characteristic narrow and winding nature of the uranium deposits due to localization along intersections and bends in ancient stream channels. In this area the mineralized channel sandstone is in the Shinarump Member of the Chinle Formation (modified from Chenoweth, 1991).



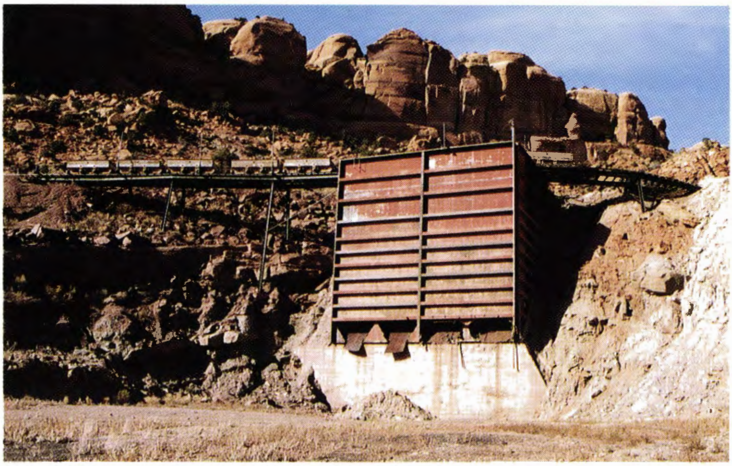
Loaded cars of uranium ore are brought out of a mine in the Red Canyon area, circa 1950. Photo courtesy Utah Historical Society.

With the recent drop in uranium prices, mines and mills in San Juan County have shut down. The Lisbon Mill closed in 1988, leaving one operating mill (White Mesa Mill) in the county. The White Mesa Mill in Blanding accounted for the major production of all U.S. uranium and vanadium production in 1989, and in 1990 it was the only conventional uranium mill still operating in the United States. The mill and some of the supporting mine operations closed in December 1990, but re-opening these facilities is anticipated. Considerable uranium reserves still exist in San Juan County and market demands of uranium-vanadium will determine the feasibility of re-opening mines and mills.

The three major uranium producing areas in San Juan County have been Lisbon Valley, White Canyon, and Monument Valley. Lisbon Valley has produced more uranium than any other area in Utah and is the most productive uranium area from the Chinle Formation on the entire Colorado Plateau. Originally called the Big Indian mining district, this area was responsible for making San Juan County Utah's largest uranium producer for many years. While there is much ore left in Lisbon Valley, the economical concentrations of uranium ore in Monument Valley were mined out during the AEC procurement years.

Serendipity at the Mi Vida: The story of the world's first uranium millionaire

In the early 1950s, uranium was mined from small claims along the western slope of the Lisbon anticline in the upper Cutler Formation (Permian age). In 1951, a young prospector from Texas visited the area and staked 12 claims. Charles A. Steen obtained a core drilling rig which he used on his claim named "Mi Vida" to drill down to the Cutler. From the beginning, Steen's drilling operations hung by a tenuous thread. The rig broke down several times, and Steen borrowed money to keep drilling. When he made one last-ditch effort to reach the Cutler Formation, the drill



Ore bins and hauling area for the Mi Vida mine.

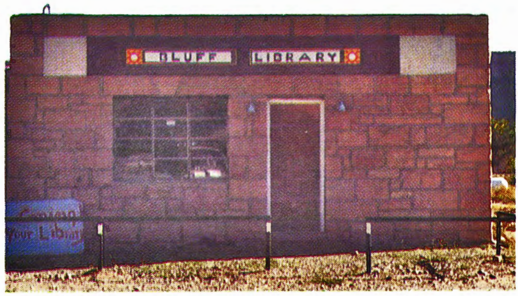
broke again. Although still 100 feet away from where he hoped to reach the uranium ore, Steen removed some of the rock cores from the drill pipe and later tested the rocks. To Steen's amazement, the rocks were high in uranium content! He had drilled into the top 14 feet of a very rich and extensive uranium deposit located in the basal Chinle Formation (the basal member later became known as the Moss Back Member). Within a year, he mined over a million dollars worth of ore from the Mi Vida mine.

The Big Indian mining district, better known now as Lisbon Valley mining district, is the site of the renowned Mi Vida mine.

Non-Metals

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

- ***How are non-metals formed?*** Non-metallic commodities are formed by several geologic processes including igneous, sedimentary, metamorphic, and weathering. For example, sedimentary processes created sandstone, limestone, sand and gravel, potash and other evaporites in the Paradox basin. Igneous processes can create gemstones, and weathering of other minerals can form clays.



The Bluff library, formerly the county jail, was constructed with hand-hewn sandstone blocks .

Exploration history and current trends – Early inhabitants of the area used stone implements as long as 10,000 years ago. The Anasazi Indians (about A.D. 1 to A.D. 1300) utilized the geologic landforms and resources, living in caves eroded into the sandstone walls, and later employing stone-mason skills to construct dwellings in the cliffs and on the mesa tops. Pictographs found on rock walls were drawn with various colors derived from minerals, such as red from clay and yellow from uranium. Pottery was made from local clay.

Pioneers settled Bluff, San Juan County's first community, in 1880. After chiseling and blasting their way through the rugged canyon country, crossing Glen Canyon at the Hole in the Rock trail, and lowering wagons down a canyon wall, they finally reached good farm lands at the mouth of Cottonwood Canyon on the San Juan River. Instead of continuing on to their original destination further up river, they stopped and established the town of Bluff. Local stone was quarried to construct many of the buildings.

Many professional and amateur rockhounds collect the varied gemstones of San Juan County. Among the beautiful specimens found are agate, petrified wood, and garnet.

Clay has been utilized for making brick and pottery in the county. Most clay prospecting takes place on the Navajo Indian Reservation; it has also been extracted from the Cretaceous-age Dakota Sandstone near Monticello.

San Juan County commodities that have potential to be mined in the future include salt, potash, magne-

Older stone structures are these Anasazi cliff dwellings on the San Juan River (photo Gary Bilger).

Garnet is found on the Navajo Indian Reservation, often associated with volcanic vents (diatremes) in the Comb Ridge area. Shown here is Alhambra Rock, a volcanic vent south of Mexican Hat (photo Jay Nethercott).

sium, and gypsum in the Paradox Formation. Potash and salt are currently extracted to the north in Grand County from a large mine near the Colorado River. The solution mining operations extend into San Juan County.

Zeolites are a potential commodity in the Jurassic-age Morrison Formation in the Lisbon Valley and Montezuma areas of San Juan County, although purity and continuity of the deposits are not known. Zeolites develop when volcanic ashes are altered by chemicals in ground water. These minerals have potential for versatile uses like air-pollution control, waste-water treatment, and absorption of radionuclides from nuclear waste.

Scenery

How the scenery came to be – Rocks are the scenery makers of San Juan County. Multi-colored sandstones and other sedimentary rocks exhibit brilliant, breath-taking hues of pink, red, gold, orange, and purple. The rocks are sculpted by wind and water, forming hundreds of colorful canyons, sharp mesas, buttes, and unique rock shapes.

Like the generation of the other geologic resources of San Juan County, the processes responsible for today's scenery have been operative over long periods of geologic time. Ancient sediments deposited and sandwiched together formed layers of sandstone, shale, limestone, and siltstone. Chemical substances formed during deposition or carried into the rock by ground water contributed to the rock coloration. Typically, red, yellow, and brown colors resulted from iron compounds. After the area was uplifted, the Colorado River and its tributaries exposed these colorful rock layers by cutting deep canyons.

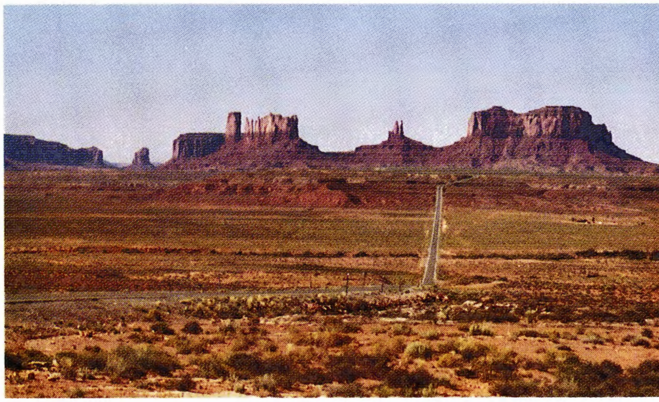
Erosion by water, wind, and ice chiseled rock formations into unique shapes. Because rock types vary in hardness, softer rocks like shale and siltstone erode faster than harder rock like sandstone. Mesas and buttes stand tall because they are capped by erosion-resistant rocks. The underlying slopes consist of softer rocks, which erode and undermine the cliffs above. The upper rocks break along vertical joints, or cracks, creating the steep cliffs. Through this continuing process, mesas become buttes and monuments, and finally spires, before crumbling down to particles of sand.

Joints are fractures in rocks, which expand by erosion once they are exposed at the surface. Water, ice, and wind action enlarge these cracks – creating spires and fins. In the fins, unusual rock openings sometimes form along softer rock layer contacts. Arches, bridges (an arch over a stream), or windows can develop.

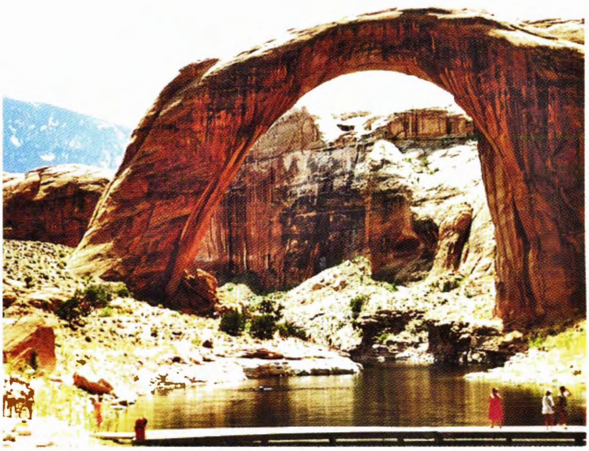
Chesler Park in Canyonlands National Park is a beautiful natural meadow surrounded by a forest of sandstone "needles." Erosion along vertical joints in the sandstone created the spires. Photo courtesy Utah Travel Council.

Scenic attractions – This unusual and magical landscape attracts hundreds of thousands of tourists and recreationists annually to the numerous parks, monuments, recreation areas, and scenic areas in southeastern Utah: Canyonlands National Park, Natural Bridges National Monument, Rainbow Bridge National Monument, Glen Canyon National Recreation Area, Monument Valley Navajo Tribal Park, Dead Horse Point State Park, Goosenecks of the San Juan State Park, and Valley of the Gods Scenic Area (see map on back cover).

Canyonlands National Park displays the spectacular layer-cake geology that characterizes the Colorado Plateau. Labyrinths of canyons, carved by rivers, slice deep through the rock strata. Alternating cliffs and slopes have formed along the various layers of sandstone, shale, siltstone, and limestone, and are brought to full view at overlooks or along the rivers. Canyonlands contains remarkable and diverse geologic wonders: mazes of narrow deep canyons, fins of rocks separated by cracks wide enough to walk through, sculptured and color-banded rock spires, petrified sand dunes, as well as arches, bridges, and windows.

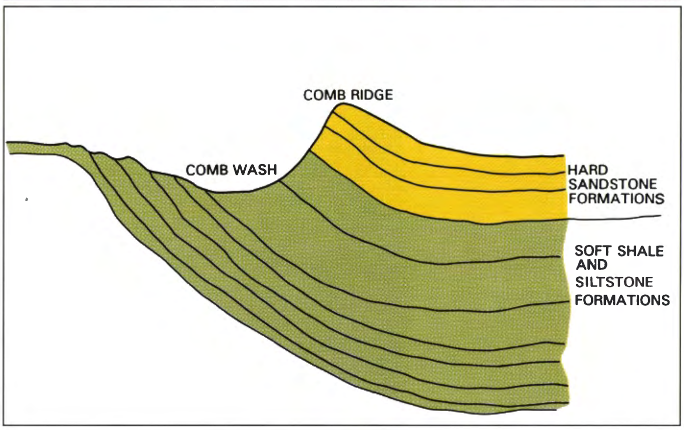


Monument Valley, Utah. The outstanding monuments are erosional remnants of a once-continuous layer of the De Chelly Sandstone (Permian age), underlain by the more easily eroded Organ Rock Shale.



Rainbow Bridge, formed in the Jurassic-age Navajo Sandstone, is 300 feet high, making it the largest known natural bridge. The water shown here is not the stream responsible for creating the bridge, but is an arm of man-made Lake Powell. Photo courtesy Utah Travel Council.

The Goosenecks of the San Juan River is where the river makes three tight loops in one and one–half miles. The overlook into the 1,500-foot chasm carved by the river provides a view of a famously classic example of entrenched meanders (a deep canyon cut by a rejuvenated river), the meandering course having been acquired in a former cycle when the river was flowing on a flat plain. The San Juan River meanders were established on such a plain, and when the Colorado Plateau slowly uplifted, the river became entrenched in hard rocks, cutting downward as it followed its original meander pattern.



Comb Ridge, west of Bluff and Blanding, is a distinctive hogback,or ridge produced by resistant rock layers that are steeply tilted. The elongate ridge, approximately 40 miles long, formed along steeply tilted sandstone formations. Rock layers on each side of the ridge are nearly flat-lying.

Areas with names like The Maze, The Needles, The Grabens, Island in the Sky, and Monument Basin are fitting testimony to the grandeur of this landscape.

The majestic monuments in Monument Valley, the statuesque figures in Valley of the Gods, and the fantastic rock bridges in Natural Bridges National Monument are all sculpted from similar sandstone. Monument Valley is a popular set for western movies and commercials; Natural Bridges National Monument contains the largest display of natural bridges in the world (three huge bridges).

Rising to over 10,000 feet (the La Sals peak to 12,721 feet), the isolated mountain areas in San Juan County offer contrast to the desert. Snow cover in the winters and cool temperatures in the summers provide many recreational opportunities.

San Juan County is also a place to see cultural and archaeological resources in their natural setting. Petroglyphs are etched into the smooth canyon walls and rocks. Stone and adobe ruins are found from the canyon bottoms to the mesa tops, as well as precariously situated in the cliff walls. Newspaper Rock State Park exhibits an elaborate panel of petroglyphs, Hovenweep National Monument is a haunting area with remarkable stone towers built out in the open, Edge of the Cedars State Park displays mesa-top ruins, and Grand Gulch Primitive Area is one of the richest archaeological areas in Utah.

What About the Future?

Formation of geologic resources requires long periods of time and occurs under specific geologic conditions. Just as the earth has boundaries, so do the natural resources. Because we can exhaust some economic deposits in just a few decades, an alarming 0.00001 percent of the time it took to create them, most resources are finite and nonrenewable. Resources play an important role in our economy and quality of life, yet the daily rate at which we use these limited supplies poses accelerating serious dilemmas.

Increased competition for land use (recreation areas, wilderness designations, urban development, mineral extraction, agriculture) and growing environmental concerns have created controversial political, environmental, and economical issues. Questions need resolutions with insight, such as how can nuclear waste be disposed of safely; should oil drilling or mining be allowed in critical wildlife habitats, in valuable environmental areas, in cultural resource areas, in scenic areas; or should new wilderness areas be designated where there may be potential for large mineral concentrations. In some cases, resource development may be deemed compatible with preservation of other resources.

San Juan County's cultural and land-use diversities exemplify the conflicts emanating from the growing demands of oil drilling, mining, recreation, and wilderness area designation. Traditional land-users like the Navajo and Ute Indians struggle to balance resource development with their cultural and environmental values; even wilderness area designations can restrict Native Americans' ancestral livelihoods. As recreation and tourism expand, conflicts escalate between the demands of tourists, recreationists, extractive industries, wildlife protectors, environmentalists, and private landowners.

We need to resolve resource issues now; as our population increases, resource consumption increases, and the already limited resource supplies decrease. In order to reach wise resolutions, it is essential that we be sufficiently informed. Awareness of the long-term consequences of our decisions is critical. For what we decide now will affect future generations, or, stated more eloquently by the Native Americans,

"we don't inherit the earth from our ancestors, we borrow it from our children."

The following list of references provided information for this brochure

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

Campbell, J.A., 1978, Carbon dioxide resources of Utah: Utah Geological and Mineral Survey Report of Investigation 125, 36 p.

Chenoweth, W.L., 1984, Early uranium-vanadium mining in Monument Valley, San Juan County, Utah: Utah Geological and Mineral Survey, Survey Notes, v. 18, no. 2, 2 p.

–1990a, Developments in uranium in 1989: American Association of Petroleum Geologists Bulletin, v. 74, no. 10B, p. 380-386.

–1990b, Lisbon Valley, Utah's premier uranium area, a summary of exploration and ore production: Utah Geological and Mineral Survey Open-File Report 188, 45 p.

–1991, The geology and production history of the uranium-vanadium deposits in Monument Valley, San Juan County, Utah: Utah Geological Survey Contract Report 91-4, 55 p.

Clem, K.M., and Brown, K.W., 1984, Petroleum resources of the Paradox Basin: Utah Geological and Mineral Survey Bulletin 119, 162 p.

Cohenour, R.E., 1969, Uranium in Utah *in* Jensen, M.L., editor, Guidebook of northern Utah: Utah Geological and Mineral Survey Bulletin 82, p. 231-249.

Dixon, H.B., 1938, The building and monumental stones of the state of Utah: Provo, Brigham Young University, thesis, 75 p.

Doelling, H.H., 1969, Mineral resources, San Juan County, Utah, and adjacent areas, Part II uranium and other metals in sedimentary host rocks: Utah Geological and Mineral Survey Special Studies 24 (II), 64 p.

–1983, Non-metallic mineral resources of Utah: Utah Geological and Mineral Survey Map 71, scale 1:750,000.

Doelling, H.H., and Smith, M.R., 1983, Overview of Utah coal fields, 1982: Utah Geological and Mineral Survey Reprint 103, 26 p.

Doelling, H.H., and Tooker, E.W., 1983, Utah mining district areas and principal metal occurrences: Utah Geological and Mineral Survey Map 70, scale 1:750,000.

Energy Information Administration, preparer, 1990, Uranium industry annual 1989: Energy Information Administration, U.S. Department of Energy DOE/EIA-0478(89), 121 p.

Hintze, L.R., 1975, Geologic highway map of Utah: Brigham Young University Geology Studies Special Publication 3, scale 1:1,000,000.

– compiler, 1980, Geologic map of Utah: Utah Geological and Mineral Survey Map A-1, scale 1:500,000.

–1988, Geologic history of Utah: Brigham Young University Geology Studies Special Publication 7, 202 p.

Powell, A.K., editor, 1983, San Juan County, Utah–people, resources, and history: Salt Lake City, Utah State Historical Society, 352 p.

Ritzma, H.R., 1979, Oil-impregnated rock deposits of Utah: Utah Geological and Mineral Survey Map 47, scale 1:1,000,000.

Ritzma, H.R., and Doelling, H.H., 1969, Mineral resources, San Juan County, Utah, and adjacent areas, Part I petroleum, potash, groundwater, and miscellaneous minerals: Utah Geological and Mineral Survey Special Studies 24, 125 p.

Shumway, Gary L., 1983, Uranium mining on the Colorado Plateau *in* Powell, A. K., editor, San Juan County, Utah: people, resources, and history: Salt Lake City, Utah State Historical Society, p. 265–298.

Smith, M.R., 1982, Mineral resources of the Paradox Basin of Utah: Utah Geological and Mineral Survey, Survey Notes, v. 16, no. 2, p. 8-11.

–1987a, Industrial commodities: Non-metallic resources of Utah: Utah Geological and Mineral Survey Miscellaneous Publication 87-4, fold-out.

–1987b, Mineral fuels and associated energy resources: Utah Geological and Mineral Survey Miscellaneous Publication 87-2, fold-out.
Staley, Don, preparer, 1991, Report of Utah oil and gas activity 1990: Division of Oil, Gas and Mining, 25 p.
Stokes, W.L., 1986, Geology of Utah: Utah Geological and Mineral Survey and Utah Museum of Natural History, Utah Geological and Mineral Survey Miscellaneous Publication S., 317 p.
Stowe, C.H., 1974, Utah's mineral activity: an operational and economic overview: Utah Geological and Mineral Survey Bulletin 105, 34 p.
1979, Rockhound guide to mineral and fossil localities in Utah: Utah Geological and Mineral Survey Circular 63, p. 55-57.
Tripp, B.T., and Mayes, B.H., 1989, Zeolite occurrences of Utah: Utah Geological and Mineral Survey, Survey Notes, v. 23, no. 3, p. 2-13.
U.S. Geological Survey, compiler, 1964, Mineral and water resources of Utah: Utah Geological and Mineral Survey Bulletin 73, 275 p.
Utah Division of Oil, Gas and Mining, 1991, Oil and gas production report: Utah Division of Oil, Gas and Mining, 12 p.
Utah Geological and Mineralogical Survey, compiler, 1966, Gold placers in Utah: Utah Geological and Mineralogical Survey Circular 47, 29 p.
Utah Geological and Mineral Survey, compiler, 1983, Energy resources map of Utah: Utah Geological and Mineral Survey Map 68, scale 1:500,000.
Utah Geological Survey, compiler, Utah mineral occurrence system (UMOS): Utah Geological Survey unpublished minerals section data.
Utah Mining Association, Management Digest: Salt Lake City, Utah Mining Association, published monthly.
Wiegand, D.L., editor, 1981, Geology of the Paradox Basin: Rocky Mountain Association of Geologists 1981 Field Conference, 285 p.
Woodward-Clyde Consultants, 1983, Overview of the regional geology of the Paradox Basin study region: ONWI-92, prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Table 1

Known energy occurrences in San Juan County. Since mining and drilling activity depend on fluctuating economic conditions, not all of the resources listed below are currently being extracted.

San Juan County Energy Resources

Commodity	Uses	Location	Occurrence
Carbon Dioxide	dry ice compressed gas enhanced oil recovery	Bluff field Gothic Mesa field	contact metamorphism of carbonate rocks
Coal	fuels industrial products	Eastern San Juan County	subbituminous or bituminous in Cretaceous Dakota Sandstone
Oil & Gas	asphalt fuels plastics solvents waxes	Paradox basin - more than 50 fields in the basin.	Permian, Pennsylvanian, Mississippian, and Devonian sedimentary formations
Tar Sand	fuel paving material	Mexican Hat White Canyon	Pennsylvanian carbonates Permian sandstones
Geothermal	electricity heating	Northern San Juan County	

Table 2

Known metallic occurrences in San Juan County. Since mining activity depends on fluctuating economic conditions, not all the resources are currently being extracted.

San Juan County Metallic Resources

Commodity	Uses	Mining District or Area	Occurrence*	Ore Minerals	Associated Metals
Copper	alloys ammunition coinage construction electrical prods. heat exchangers plumbing transportation	Abajo Mtns Lisbon Valley Deer Flat Elk Ridge Fry Canyon Indian Creek Interriver La Sal Mtns Lower Cane Creek Monument Valley Red Canyon White Canyon	veins replacement diss., bedded, replace bedded, disseminated replacement, diss. veins, cont. meta. bedded, replace, diss. bedded, replacement bedded, diss., replace	azurite bornite chalcocite chalcopyrite chrysocolla copper covelite cuprite malachite	gold lead silver molybdenum uranium vanadium zinc
Gold	currency dentistry electronics jewelry ornaments	Abajo Mtns. Green River San Juan River Colorado River La Sal Mtns.	placer, veins placer placer placer placer, veins	native gold	copper gypsum lead platinum silver zinc

San Juan County Metallic Resources, cont.

Commodity	Uses	Mining District or Area	Occurrence*	Ore Minerals	Associated Metals
Lead	batteries construction electrical prods. gas additive glass paint	Abajo Mtns. Lisbon Valley White Canyon	veins diss., bedded, replace	galena gummite	copper gold silver zinc
Moybdenum	aircraft automotibles chemicals machine tools	White Canyon Red Canyon	bedded bedded	ilsemannite jordisite molybdenite	copper uranium
Silver	alloys dentistry electrical prods. jewelry photography sterlingware	Abajo Mtns. La Sal Mtns.	veins veins, cont. meta.	eucarite	copper gold lead zinc
Uranium	nuclear fuels nuclear weapons radioisotopes x-ray targets	scattered throughout Colorado Plateau. Major deposits in Big Indian Valley (Lisbon Valley), White Canyon, and Monument Valley	disseminated, bedded, and replacement deposits found in Permian, Triassic and Jurassic sedimentary formations	carnotite metatyuyamunite uraninite	copper
Vanadium	steel alloy	found with uranium	disseminated, bedded, and replacement deposits found in Permian, Triassic and Jurassic sedimentary formations	carnotite corvusite metarossite metatyuyamunite montroseite pascoite roscoelite simplotite	copper
Zinc	alloys brass construction electrical prods. machinery photocopying pigments	Abajo Mtns. Lisbon Valley	veins disseminated, bedded, replacement	sphalerite	copper gold lead silver

*Abbreviations for occurrence type: replace = replacement; diss = disseminated, cont meta = contact metamorphic.

Table 3

Known non-metallic occurrences in San Juan County. Since mining activity depends on fluctuating economic conditions, not all of the resources listed below are currently being extracted.

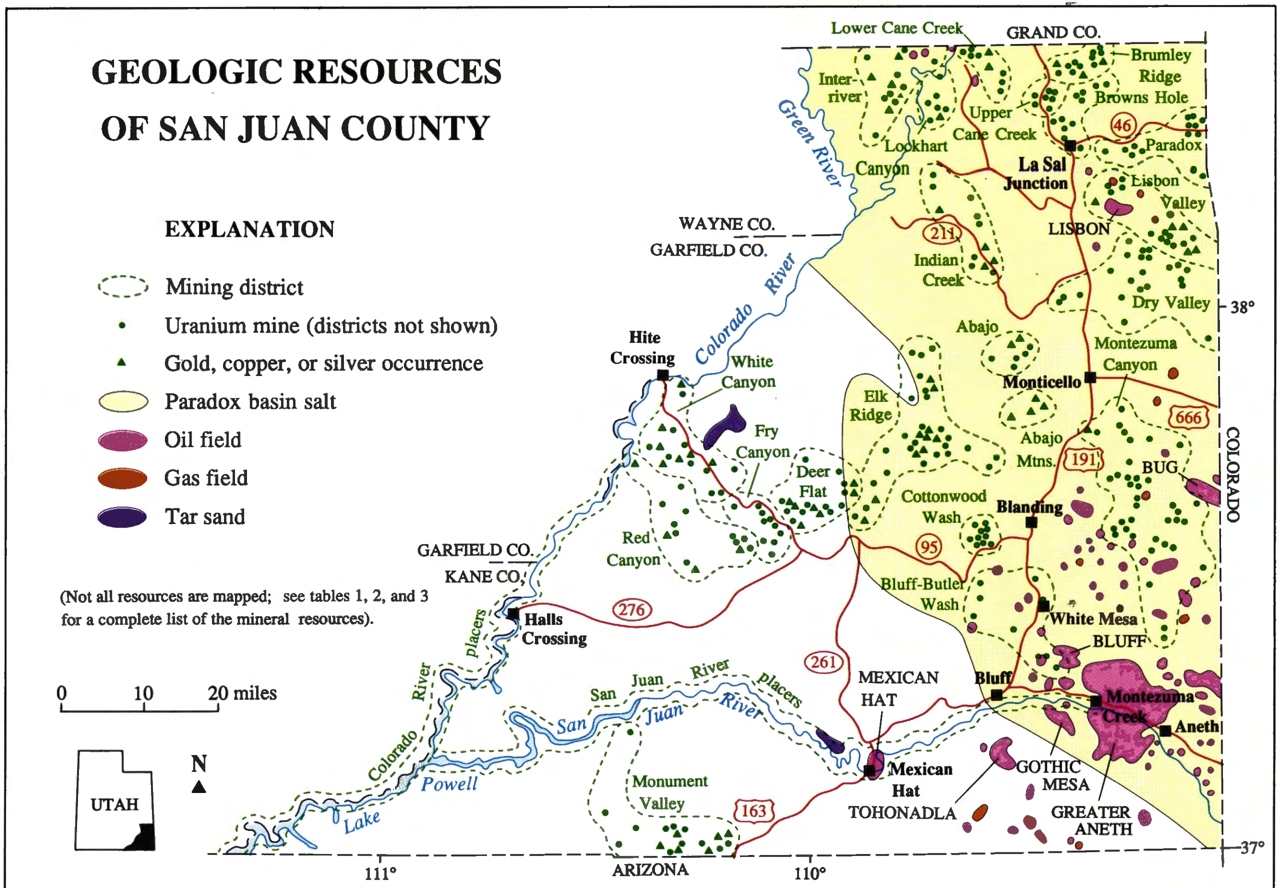
San Juan County Non-metallic Resources

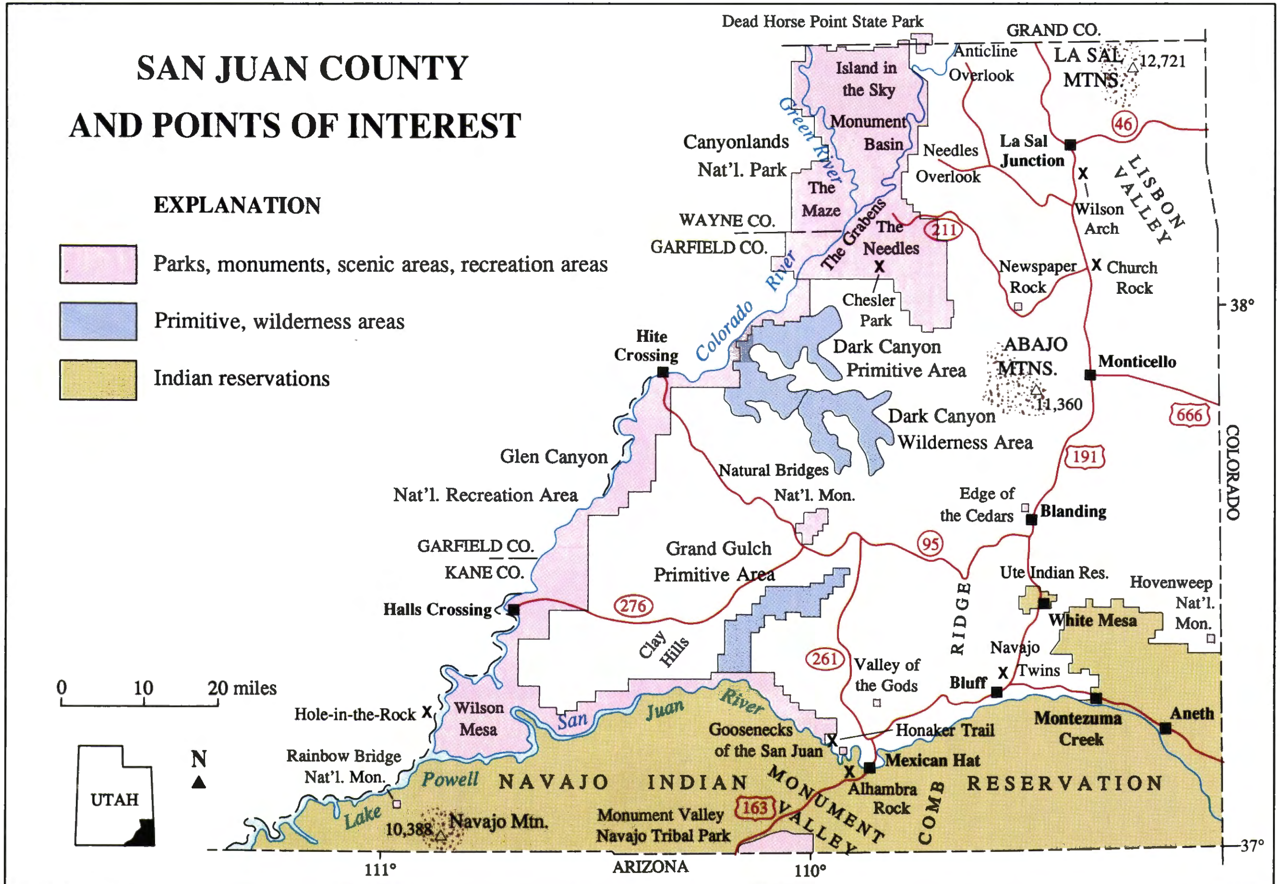
Commodity	Uses	Location	Occurrence
Boron*	borax products	Paradox basin	Paradox Formation
Bromine*	chemicals	Paradox basin	Paradox Formation
Clays			sedimentary
kaolinite	brick fire clay tile	Abajo Mtns. La Sal Mtns. Monticello area	
bentonite	drilling mud lining water structures	Bluff area Clay Hills Comb Ridge Monument Valley	
Gemstones			
agate	ornamental	La Sal Junction	aqueous solutions filling cavities and veins

San Juan County Non-metallic Resources, cont.

Commodity	Uses	Location	Occurrence
amethyst	ornamental	La Sal Mtns.	
jasper	ornamental	Paradox basin	
peridot	abrasives	Comb Ridge	found in alluvium, associated with volcanic vents
petrified wood	bookends ornamental	Paradox basin	fossil, wood replacement, in Chinle and Morrison Formations
pyrope garnet spessartite garnet	abrasives jewelry ornamental	Comb Ridge area	found in alluvium, associated with volcanic vents
Gypsum	sculpting material (alabaster) soil conditioner wallboard	Paradox basin	Paradox Formation
Lithium*	ceramics electric batteries lubricants	Paradox basin	Paradox Formation
Magnesium*	aluminum alloys castings	Lisbon Valley	Paradox Formation
Potash*	fertilizer	Paradox basin	Paradox Formation
Quartz	abrasives chemicals fluxes glass	Wilson Mesa	
Salt (halite)*	animal feed supplement chemical industry ice control food water softeners	Paradox basin	Paradox Formation
Sand and Gravel	aggregate for concrete bituminous aggregate construction fill filtration railroad ballast winter road safety	Blanding area Bluff area Cottonwood Wash La Sal Mtns. Montezuma Canyon Monticello area Monument Valley	sedimentary, igneous, and metamorphic
Stone			
sandstone	dimension stone crushed stone	Blanding area Bluff area Montezuma Canyon	sedimentary
limestone	dimension stone cement manufacture crushed stone lime manufacture	Mexican Hat Monument Valley San Juan River Canyon	sedimentary
diorite porphyry	crushed stone	Abajo Mtns. La Sal Mtns.	igneous (volcanic)
Zeolites*	air pollution control construction detergent dietary supplement for livestock mining and metallurgy nuclear waste disposal odor control solar energy waste-water treatment	Lisbon Valley Montezuma Creek area	altered tuffs in Morrison Formation

*Potential commodities


GEOLOGIC RESOURCES
OF SAN JUAN COUNTY
EXPLANATION
Mining district
Uranium mine (districts not shown)
Gold, copper, or silver occurrence
Paradox basin salt
Oil field
Gas field
Tar sand
(Not all resources are mapped; see tables 1, 2, and 3 for a complete list of the mineral resources).
0 10 20 miles
UTAH
N
Lower Cane Creek
GRAND CO.
Brumley Ridge
Browns Hole
Inter-river
Upper Cane Creek
Lockhart Canyon
Paradox
La Sal Junction
Lisbon Valley
LISBON
Green River
WAYNE CO.
GARFIELD CO.
Colorado River
211
Indian Creek
Dry Valley
38°
Abajo
Montezuma Canyon
Hite Crossing
White Canyon
Monticello
Elk Ridge
666
Fry Canyon
Abajo Mtns.
191
BUG
Deer Flat
Cottonwood Wash
Blanding
COLORADO
Red Canyon
95
GARFIELD CO.
KANE CO.
Bluff-Butler Wash
276
Halls Crossing
White Mesa
placers
BLUFF
261
River
MEXICAN HAT
Bluff
San Juan River placers
Montezuma Creek
Aneth
San Juan River
Colorado
Powell
Lake
Mexican Hat
GOTHIC MESA
Monument Valley
163
TOHONADLA
GREATER ANETH
37°
111°
ARIZONA
110°


SAN JUAN COUNTY
AND POINTS OF INTEREST
EXPLANATION
Parks, monuments, scenic areas, recreation areas
Primitive, wilderness areas
Indian reservations
0 10 20 miles
UTAH
N
Dead Horse Point State Park
GRAND CO.
Anticline Overlook
LA SAL MTNS.
12,721
Island in the Sky
Monument Basin
Green River
Canyonlands Nat'l. Park
Needles Overlook
La Sal Junction
46
LISBON VALLEY
The Maze
WAYNE CO.
GARFIELD CO.
The Grabens
The Needles
211
Wilson Arch
Newspaper Rock
Church Rock
Chesler Park
Colorado River
38°
Hite Crossing
Dark Canyon Primitive Area
ABAJO MTNS.
11,360
Monticello
666
Dark Canyon Wilderness Area
COLORADO
Glen Canyon Nat'l. Recreation Area
Natural Bridges Nat'l. Mon.
191
Edge of the Cedars
Blanding
GARFIELD CO.
KANE CO.
Grand Gulch Primitive Area
95
Ute Indian Res.
Hovenweep Nat'l. Mon.
COMB RIDGE
Halls Crossing
276
Clay Hills
White Mesa
Navajo Twins
261
Valley of the Gods
Bluff
Hole-in-the-Rock
Wilson Mesa
San Juan River
Goosenecks of the San Juan
Honaker Trail
Montezuma Creek
Aneth
Rainbow Bridge Nat'l. Mon.
Mexican Hat
Alhambra Rock
Lake Powell
NAVAJO INDIAN RESERVATION
MONUMENT VALLEY
10,388
Navajo Mtn.
Monument Valley Navajo Tribal Park
163
37°
111°
ARIZONA
110°