
HISTORY OF UTAH'S OIL SHALE INDUSTRY

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INTRODUCTION

During the 1800s, western pioneers were introduced to oil shale by Native Americans referring to it as “the rock that burns.” An early Mormon retort in Juab County, Utah, supposedly produced small quantities of shale oil for lubricants around 1850. However, it wasn't until about 1915 that the vastness of the oil shale resource in the western United States was fully realized and the potential for producing transportation fuels from oil shale was recognized.

The efforts to develop an oil shale industry in Colorado, Utah, and Wyoming have had a history of “boom and bust,” with activity increasing when the price of crude oil increased, then, when the price of crude oil dropped, activity would go essentially dormant for decades. Over the past 100 years, industry and government agencies have repeatedly demonstrated that technology exists to produce synthetic crude oil from oil shale rock, and that this synthetic oil can be upgraded to a premium refinery feedstock that yields excellent transportation fuels. Nevertheless, a commercial oil shale industry in the United States does not currently exist, largely because the cost of producing synthetic crude from oil shale has been more expensive than that of producing crude oil from conventional wells. Also, discoveries of domestic and international conventional crude, along with new technologies to enhance recovery, have continued to meet growing world-wide demand.

All the same, many believe that oil shale is such a huge domestic resource that it will eventually be processed to produce synthetic crude to help meet the nation's demand for transportation fuels. New or improved technologies will eventually be developed to make this resource more competitive with conventional crude.

Building a commercial oil shale operation today is capital-intensive and requires a long lead-time for permitting, design engineering, and construction, well over 10 years. An investor has no certainty on what the price of oil will be that far into the future. Also, the oil shale resource in the western United States is largely controlled by the federal government and there has been no consistent oil shale leasing program and no long-term federal initiatives or incentives to develop this vast oil shale resource. Both circumstances have been a deterrent to private industry investing in oil shale as the federal rules, regulations, and programs have been inconsistent over the past 100 years.

This paper briefly reviews the 100-year history of oil shale activities in Utah. The author has been an active participant since 1974 and continues to work on oil shale projects across the United States.

THE FIRST BOOM PERIOD

Lands

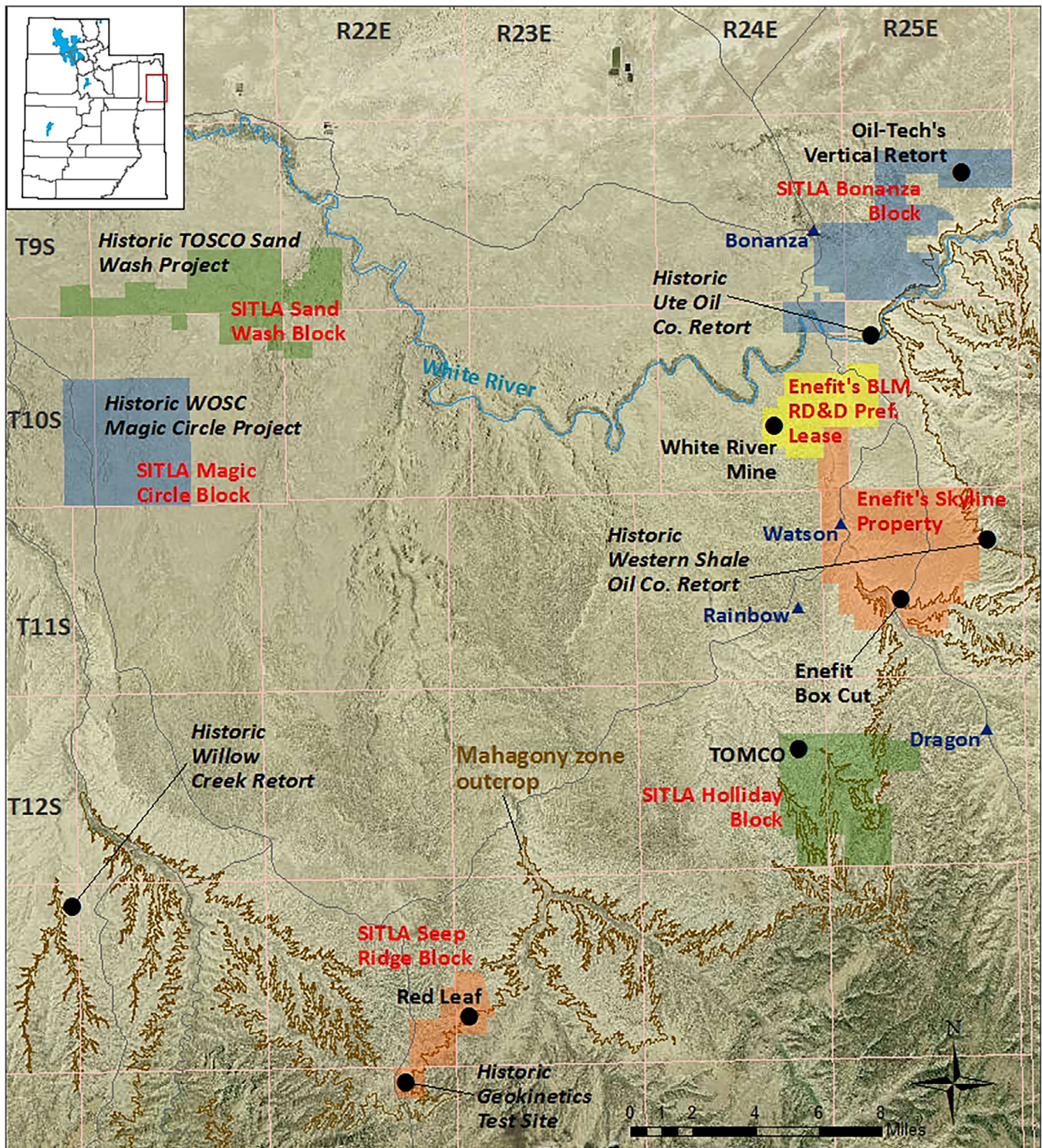
An oil shale industry existed in Europe as early as 1851, and small plants operated in the eastern United States prior to 1859, the year of Drake's first oil well discovery near Titusville, Pennsylvania. After 1859, conventional crude oil wells and refineries in the eastern United States flourished for decades and adequately met the needs of the nation. As the automobile came on the scene in the early 1900s, the demand for transportation fuels increased dramatically. With the beginning of World War I in 1914, there was concern whether the U.S. military would have sufficient transportation fuels in light of the growing demand. In 1915, the U.S. Geological Survey, while studying potential oil-bearing formations in the western United States, reported on the kerogen-bearing oil shale deposits of Colorado, Utah, and Wyoming (Alderson, 1919). For an oil-thirsty nation, this created a get-rich opportunity, as hundreds of people descended on the region to stake oil shale mining claims on Green River Formation outcrops.

Under the General Mining Law of 1872, a 160-acre placer mining claim could be staked by a group of eight people, each responsible for 20 acres. The 1872 Mining Law required the claimants to perform the equivalent of \$100 worth of work on the claim annually and file an affidavit stating the work had been performed. After 5 years, the claimants could file a patent application for the 160-acre claim. If a federal mineral examiner agreed that the claimant had performed the necessary work and in the process demonstrated that oil shale was present on the claim and that it could likely be extracted economically, the federal government would issue the patent or deed to the land, making it private property.

Between 1915 and 1920, over 30,000 oil shale claims were filed in the three-state region by prospectors, geologists, engineers, and ordinary citizens. Since it was necessary to demonstrate the presence of oil shale on the claim, most were staked along the oil shale outcrops or erosional features where the shale was visible. Rich oil

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Map showing the locations of several oil-shale-related lands and projects in Uintah County, Utah **Map credit:** M. Vanden Berg, Utah Geological Survey

shale beds of the Piceance Creek Basin are visible over large areas of northwestern Colorado, particularly along the Colorado River, and this region became a mecca for much of the early oil shale activity in the United States. In the Uinta Basin of northeastern Utah, rich oil shale beds are exposed along the White River and its tributaries and along the basin's southern edge. In southwest

Wyoming, the richer oil shales are exposed in portions of the Green River and Washakie Basins. Again, it was these outcrop areas that drew the early attention and became the focus of early oil shale pioneers.

As a result of the oil shale frenzy and the land rush to the region, the federal government passed The Mineral Leas-

ing Act of 1920 that designated which minerals must be leased from the federal government, and thus were no longer available for claim staking under the 1872 Mining Law. This 1920 law included oil shale. In essence it said that after 1920, anyone wanting to work oil shale on federal land had to get an oil shale lease from the federal government. However, the federal government conceded that the pre-1920 oil shale claims could be maintained and managed under the 1872 Mining Law, and the claimants could still apply for patent and, if successful, get a patent or deed to the land.

In order to assure a supply of military fuel, in 1916 President Wilson set aside certain federal oil shale lands in both Colorado and Utah as Naval Oil Shale Reserves (NOSR). Initially, NOSR #1 in Colorado consisted of 45,444 acres and NOSR #2 in Utah contained 86,584 acres. These areas were later expanded in 1924 by President Coolidge, who added 23,000 acres in Colorado and 4880 in Utah. NOSR #3 in Colorado was added in 1924 to provide valley-bottom property for plant site development.

Between 1915 and 1930, over 300,000 acres of the pre-1920 oil shale mining claims were patented, mostly in Colorado, followed by Utah, and then Wyoming. Other unpatented oil claims were maintained in accordance with the 1872 Mining Law and some of those were finally successfully patented in the 1990s. Other pre-1920 claims were held by claimants for decades and became the subject of disputes with the federal government when the claimants filed for patent and the government challenged the validity of the claims. The final disputes on Utah oil shale mining claims, to be discussed later, were settled in 2009. Today the federal government contends that all pre-1920 unpatented oil shale mining claims are no longer valid.

Development Activities

Shortly after 1915, developers began building small pilot plants to process oil shale, believing that eventually this would lead to large-scale commercial operations. At least 20 companies initiated plant construction in Colorado, while three companies started operations in Utah. Aside from these operations, dozens of other companies were formed with plans to build in the future. While some of these companies were quite well funded by sincere organizers, many were simply scams put forth by promoters to sell stock and pocket the proceeds. Details of most of the early pilot plants are well documented in the book *History of Western Oil Shale* (Russell, 1980). Over 40 different retorts and processes were proposed for oil shale projects. Russell did an excellent job of describing the various early-stage retorts designed to process the oil shale and the companies behind each project. His book includes several photos of the early oil shale plants and is recommended to anyone interested in an in-depth history of western oil shale.

These early efforts were, for the most part, poorly funded with no participation from major energy companies. Regardless, interest in western oil shale subsided rapidly after the discovery of giant oil fields in Texas, Oklahoma, and California during the 1920s. By 1930, every oil shale project in Colorado and Utah had been abandoned and only a few hundred barrels of shale oil were produced in these early years.

In addition to the private oil shale companies, the U.S. Bureau of Mines (USBM) had its own research program that included the opening of a mine and building two pilot-scale retorts at Rulison, Colorado. Between 1926 and 1929, the USBM produced over 3500 barrels of shale oil using both an N-T-U retort and a Pumpherson retort (Russell, 1980). This government research facility was closed and dismantled by the end of 1929.

Early Utah Oil Shale Projects

Mormon Retort

Russell (1980) researched and reported on an early Utah oil shale retort commonly referred to as the "Mormon Retort," which was built sometime around 1860 in Juab County. There is no clear record of who built the retort



*The old Mormon Retort near Levan, Juab County, Utah, photographed in 1916. Built by Mormon pioneers roughly 60 years earlier, it was the first known oil shale operation in the Rocky Mountain West, extracting as much as a barrel of oil a day from the surrounding rocks for use in dressing leather harnesses, lubricating wagon wheel axels, and lighting lamps. **Photo and caption credit:** U.S. Geological Survey; Limerick and others, 2008*

and whether it actually produced any shale oil, although the common thought is that it produced heavy oil used by pioneers as lubricants.

During the boom period between 1915 and 1930, at least three known oil shale pilot retorts were built in Utah.



The Ute Oil Company's Wallace retort under construction in about 1919. **Photo credit:** Bureau of Land Management, Vernal, Utah, file photo provided to Russell (1980).



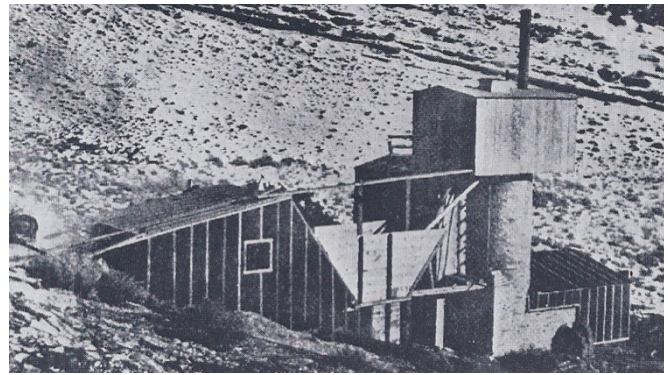
Remains of The Ute Oil Company plant site, February 2015. **Photo credit:** G. Aho, Sage Geotech Inc.

The Ute Oil Company

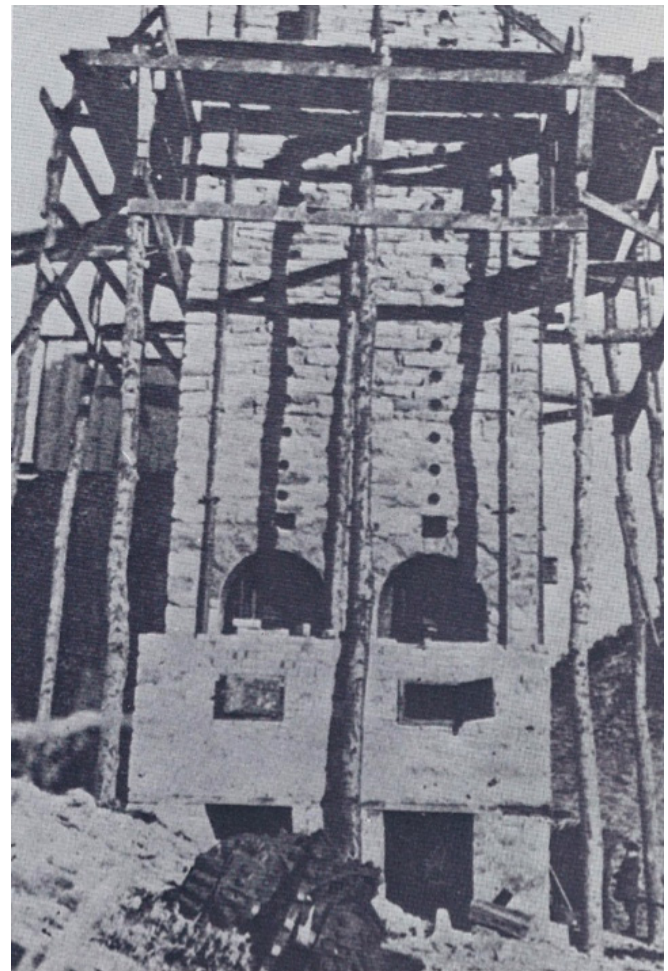
Russell (1980) reported that The Ute Oil Company started constructing a Wallace retort on the north shore of the White River, Uintah County, east of Bonanza, Utah, about 1917. There is no record of this plant ever producing shale oil and there is no mention of it after about 1922 (Russell, 1980).

The Western Shale Oil Company

Russell (1980) reported on The Western Shale Oil Company's project and included photos of the retort and



Retort plant of The Western Shale Oil Company. **Photo credit:** The Shale Review, September 1920.



Battery of four Galloupe retorts under final construction by The Western Shale Oil Company. **Photo credit:** The Shale Review, January 1921.

camp site taken in 1920 and 1921. This project built a battery of four Galloupe retorts, but shale oil production, if any, was minimal. The retorts were abandoned in about 1922. The site is in eastern Uintah County, near the Colorado state line and a short distance off the Rabbit Mountain Road.



Remains of The Western Shale Oil Company's retort, February 2015. **Photo credit:** G. Aho, Sage Geotech Inc.



When the first oil shale boom went bust in the 1920s, companies abandoned shale country as quickly as they had appeared, leaving the ruins of retorts, such as this one on Willow Creek southwest of Vernal, Utah, as monuments to their failed efforts. **Photo and caption credit:** National Energy Technology Laboratory; Limerick and others, 2008

Willow Creek Retort

This often-photographed retort is located in southern Uintah County along Willow Creek. Russell (1980) indicates that this retort was built by J. H. Galloupe, presumably

between 1917 and 1922. There are no known historic photographs, but Russell includes photos from 1978 and the retort remains today as it was when he visited.

For many years after 1930 there was little interest in oil shale and many of the original unpatented claims were surrendered by the claimants or sold to others. The nation had plenty of inexpensive oil. The stock market collapse in 1929 and the Great Depression of the 1930s severely impacted the growth in demand for transportation fuels.

Benefit of Gilsonite Development and the Uintah Railway

The early Utah oil shale projects benefited from other activity in this remote area. Gilsonite mining began in the late 1880s and grew as new gilsonite veins were discovered. To get the increased gilsonite production out of the region, the Uintah Railway was constructed in 1904 from Mack, Colorado, to Watson, Utah. This railway served the gilsonite mining communities of Dragon, Watson, and Rainbow, hauling gilsonite and wool out of the Uinta Basin and bringing crucial supplies into the region. From Watson, the Uintah Toll Road Company shuttled supplies by horse and wagon to Vernal. The railroad provided access to the basin for the early oil shale prospectors and hauled equipment and supplies for the early oil shale plants.

By 1939, many of the early gilsonite veins had been depleted and production was moving north towards Bonanza, Utah, where new veins were being developed. Production from that area was hauled by truck. The Uintah Railway service ended in 1939, and by early 1940 the rails were pulled and the towns of Dragon, Rainbow, and Watson were gradually abandoned. *Uintah Railway, The Gilsonite Route*, written by Henry E. Bender, Jr., and published in 1970, contains an excellent historical account of the Uintah Railway, including hundreds of photographs.

THE SECOND OIL SHALE BOOM

As noted above, interest in oil shale waned after about 1922 because of the discoveries of large oil fields in Texas, Oklahoma, and California that resulted in a plentiful supply of cheap oil. However, liquid fuel shortages during World War II renewed interest in oil shale by the USBM and some of the major oil companies. The U.S. Congress passed the Synthetic Liquid Fuels Act in 1944, which authorized the construction and operation of plants to produce synthetic fuels from oil shale and other materials. The USBM selected a site at Anvil Points, west of Rifle, Colorado, that was located on the Naval Oil Shale Reserve, for its oil shale research and demonstration mine and plant. USBM research included oil shale mining, pilot retort tests, and an experimental shale oil refining facility, which demonstrated that shale oil could be produced and refined into transportation fuels. Sever-

al USBM publications document the research performed at the site (e.g., East and Gardner, 1964). The USBM's program at Anvil Points was halted in 1956 when Congress determined that crude oil supplies were adequate and the development of oil shale was unnecessary. Soon after, Congress cut off funding for further research and the center was put into a standby mode.

Aside from the USBM research at Anvil Points, a few major oil companies became interested in oil shale about the time of World War II. Oil companies had begun acquiring blocks of patented oil shale mining claims, mostly in Colorado. One of the more active participants was Union Oil Company of California. The company conducted research and built a mine and retort near Parachute, Colorado, in the early 1950s. Union Oil operated this facility until 1958, when it was closed after successfully concluding its technical demonstration program.

In the late 1950s, The Oil Shale Corporation (TOSCO) constructed a pilot plant near Denver, Colorado, for the development of its TOSCO II retort technology. This research led TOSCO, Standard of Ohio, and The Cleveland-Cliffs Iron Company to form the Colony Development Company in 1964—the name Colony came from the three companies' home states—Colorado, Ohio and New York. Colony built and operated a 1000-ton-per-day TOSCO II pilot plant near Parachute beginning in 1965. This pilot plant and associated underground oil shale mine operated for a number of years and produced over 270,000 barrels of shale oil (G. Vawter, 2015, personal communication).

Shell Oil Company began research on *in situ* oil shale retorting technology in the early 1960s. In addition, the Colorado School of Mines led a research program at the USBM's Anvil Points facility between 1964 and 1968, funded by a group of six major oil companies.

While the 1950s and 1960s oil shale pilot plant activities noted above were taking place in Colorado, there was only minimal activity in Utah. A few companies, such as Skyline Oil Company and the Larson Family, were active in acquiring blocks of patented and unpatented oil shale mining claims. These lands were along the eastern and southeastern part of the Uinta Basin where the oil shale crops out.

THE THIRD OIL SHALE BOOM

By the late 1960s, interest in U.S. oil shale was again increasing as the country was becoming more dependent on imported oil to meet domestic demands. In 1971, the federal government formed an Oil Shale Task Force that was commissioned to lease federal oil shale lands and to encourage development of oil shale. Even though procedures for oil shale leasing were outlined in the 1920 Mineral Leasing Act, the U.S. Bureau of Land Management (BLM) had not leased a single acre of the vast oil shale resources in the western United States.

Then, the 1973 Arab oil embargo resulted in much higher gasoline prices, tight supplies, and shortages such that U.S. citizens were forced to wait in lines to fill their vehicles.

As a result, the U.S. Department of Energy (DOE) developed an oil shale research and development program, and the USBM expanded its oil shale research activities. It finally seemed like the time had come when the nation would pull together and develop a few commercial oil shale projects. Industry needed to be a key player and many major energy companies organized their oil shale teams and commenced research and development programs, feasibility studies, and land and water rights acquisition programs. The U.S. Congress passed legislation to encourage development of oil shale and other unconventional fuels, and both federal and state agencies established oil shale teams to monitor the developing projects.

In 1974, the U.S. Department of Interior, working through the BLM, offered for sale at auction six prototype oil shale leases; there were two leases each in Colorado (Ca and Cb), Utah (Ua and Ub), and Wyoming (Wa and Wb). Each lease covered 5120 acres and the lease provisions required the lessee to pursue diligent development of the property in order to offset some of the required lease bonus payments.

The following describes the bid amount and successful bidder(s) for the Colorado and Utah prototype leases; the BLM received no acceptable bids on the two Wyoming tracts.

Colorado Tract A (Ca): bid amount \$210.3 million; initial lessees were Gulf Oil Company and Standard Oil Company of Indiana; together they formed the Rio Blanco Oil Shale Company. Eventually, Gulf pulled out and Rio Blanco Oil Shale Company was owned by Standard of Indiana, later renamed Amoco.

Colorado Tract B (Cb): bid amount \$170.1 million; initial lessees were Atlantic Richfield (ARCO), Ashland Oil, Shell Oil, and TOSCO. Eventually the lease was transferred to the Cathedral Bluffs Oil Shale Corporation owned by Occidental and Tenneco.

Utah Tract A (Ua): bid amount \$75.6 million; bidders Sunoco and Phillips Petroleum.

Utah Tract B (Ub): bid amount \$45.1 million; bidders were Sohio, Sunoco, and Phillips, also known as the White River Shale Corp.

Note: Tracts Ua and Ub were merged into one project known as the White River Shale Project, managed by the White River Shale Corp.

In addition, the federal government, under President Carter, established the Synthetic Fuels Corporation (SFC) in 1980 to provide industry incentives to develop oil shale to meet domestic needs. Congress granted the SFC

with authority to provide \$88 billion in financial assistance to synfuels development projects.

Between 1970 and 1985, there was a flurry of oil shale activity in the western United States, mostly in Colorado. Nearly every major U.S. oil company was involved in at least one oil shale project. One major U.S. mining company, The Cleveland-Cliffs Iron Company, was involved as a project equity participant in three projects and as a mining consultant for other projects. Major U.S. engineering firms were also heavily involved in the design of the proposed plants.

Many of the companies' project files and other historical documents from this era can be found in the Tell Ertl Oil Shale Repository in the Arthur Lake Library at the Colorado School of Mines. Mr. Ertl (1914-1975) worked for the U.S. Bureau of Mines at Anvil Points and was a visionary regarding the potential for commercial oil shale development. His family funded the initial establishment of the repository in 1989 to provide public access to Mr. Ertl's personal collection of oil shale documents. It now houses oil shale documents contributed by other individuals and companies.

Colorado Projects

The intent of this paper is to focus on the oil shale development history in Utah. Nevertheless, it is worth at least noting that there were more projects and participants active in Colorado during this period from 1970-1985 than there were in Utah. This was mostly due to the fact that the oil companies had, over the preceding decades, acquired private land (patented oil shale claims) and water rights in Colorado, where the oil shale formation is thicker and of higher grade.

Most of the major oil shale companies were involved in retort pilot plant demonstration programs during these years; most noteworthy was the Paraho Corporation's multi-company demonstration project at the government's Anvil Points facility near Rifle. This project produced over 100,000 barrels of shale oil, which was shipped to Fruita, Colorado, and Toledo, Ohio, and refined into transportation fuels. Jet fuel from this oil was actually used by the Navy in military jets and performed extremely well.

Chevron opened its Red Point underground mine on Clear Creek north of Debeque, Colorado, and shale from the mine was shipped to Salt Lake City, Utah, where Chevron and Conoco built a 350-ton-per-day Staged Turbulent Bed (STB) pilot retort at Chevron's refinery site. The companies operated the retort research program for a couple years.

A number of very large oil shale projects were moving forward with final design and construction. Billions of dollars were spent on engineering and construction, and western Colorado was booming with activity. Workers from across the country came to the area to participate in the oil shale development. Major construction projects

were underway at Exxon's Colony Project, Occidental's Cathedral Bluffs Project (Cb Tract), Amoco's Rio Blanco Project (Ca Tract), and Unocal's Parachute Creek Project. Other projects in the planning phase included the Pacific Project (Sohio, Cleveland-Cliffs, and Superior Oil), Chevron's Clear Creek Project, the Mineral Oil Shale Project (Superior, Sohio, Cleveland-Cliffs), and separate projects owned by Shell, Equity Oil, Mobil, Cities Service, and others.

The Unocal project at Parachute completed construction of a 16,000-barrel-per-day Union B retort that operated until 1991. The project had a federal price guarantee, which meant if the WTI (West Texas Intermediate) crude oil benchmark price dropped below the contracted \$40 per barrel, the government would make up the difference from a pool of \$400 million. However, the Unocal project was terminated in 1991. While the retort had problems sustaining design capacity, Unocal deemed the project a success, having produced over 4.7 million barrels of shale oil (G. Vawter, 2015, personal communication).

Unfortunately for the industry, the price of oil began to decline in 1980 and then dropped dramatically in 1985, and the federal government's interest in developing oil shale disappeared almost overnight. The Synthetic Fuels Corporation was eliminated in 1986 and agency budgets were slashed. The energy companies halted their development activities and thousands of workers were laid off.

The various projects and participants, as well as the history of this time period, have been well documented. For those interested in Colorado's oil shale history, suggested reading includes *Shale Oil: Tapping the Treasure* (Loucks, 2002) and *Oil Shale History Revisited* (Mackley and others, 2012).

Utah Projects

SITLA Oil Shale Lands

When Utah became a state in 1896, the U.S. Congress agreed to grant the state certain lands to put in trust for the benefit of public institutions. The lands are managed by the Utah State Institutional Trust lands Administration or SITLA, and most of the revenues generated from these lands are used to fund the state's public schools. In Utah, the trust lands were typically sections 2, 16, 32, and 36 within each 36-section township. As a result, even today, if you examine a map of public lands in Utah, such as those within the Uinta Basin, you see these state lands dispersed within large areas of federal land administered by the BLM.

Revenues from these lands are obtained primarily from oil and gas leases and mineral leases and their related production royalties. SITLA offers certain lands within the Uinta Basin for oil shale leasing. Over the years, SITLA traded certain lands with the BLM in order to consolidate larger blocks that might be more favorable for oil shale leasing and development. Other transactions involved companies with either unpatented mining claims or with

oil shale leases on the scattered SITLA lands. SITLA's intent was to foster oil shale development in the state with the goal of generating additional revenues from oil shale projects.

John Blake of SITLA has provided a brief history of these consolidation efforts, summarized below.

In early 1973, Gulf Mineral Resources petitioned the Utah legislature to have the state acquire federal lands in the Holliday Block area where the company controlled unpatented mining claims, including claims owned by Frederick H. Larson. An "Exchange Agreement" was entered into on August 5, 1983, between the Utah Board/Division of State Lands and Gulf Oil Corporation/Frederick H. Larson, which provided that Gulf/Larson would relinquish and transfer to SITLA all rights to the petitioner's unpatented oil shale claims in the Holliday area in exchange for 20-year trust lands oil shale leases, to be issued to the claimants upon the acquisition of the affected lands by SITLA. SITLA subsequently acquired the block lands via in-lieu land selections #324 (August 5, 1983) and #325 (August 20, 1984) and Gulf/Larson was issued two 20-year trust land oil shale leases (ML 40854, approved August 15, 1983 and ML 41561, approved August 20, 1984). Both leases were subsequently cancelled on October 13, 1995, for non-payment of rentals.

The Bonanza, Magic Circle, and Seep Ridge oil shale land blocks were acquired by SITLA through state/federal land exchanges rather than in-lieu land selections. With each of these exchanges, a trust lands oil shale lessee petitioned SITLA to consolidate their leased acreage in scattered parcels into a single block of land through an exchange with the federal government. The petitioner would relinquish their oil shale leases in the offered base lands in exchange for a 20-year trust lands preference right lease in the selected block of land to be acquired by SITLA. The Ronald Reagan administration was disposed to accommodate land issues in the western states, making it possible to conclude exchanges within a relatively short time frame. The exchange numbers, lessees, and associated preference right oil shale leases for the respective oil shale land exchanges are as follows:

Bonanza Block (North) - Exchange #119, September 1983; Syntana-Utah Partnership, preference right lease ML 40862, relinquished September 7, 1993.

Bonanza Block (South) - Exchange #131, October 1986; Paraho, Inc., preference right lease ML 42749, cancelled October 16, 2002.

Magic Circle Block - Exchange #121, July 1985; Magic Circle Energy Corp., preference right lease ML 42504, cancelled September 6, 1990.

Seep Ridge Block - Exchange #130, May 1985; Geokinetics, Inc., preference right lease ML 42483, cancelled September 10, 1993.

The unusual Sand Wash Block consists of several scattered school sections and several small land blocks variously acquired by SITLA in previous years through in-lieu land selections for oil and gas potential. TOSCO Corporation obtained ownership of oil shale leases covering SITLA lands in the Sand Wash area and petitioned to consolidate its leased acreage into one giant land block through a land exchange with the federal government. The land exchange, #120, was all but complete by August 1985, when a series of unrelated law suits filed against the federal government (one by the Uncompahgre Indian Reservation and another by the National Wildlife Federation) derailed the action. After years of legal wrangling by the federal government, Exchange #120 was abandoned when TOSCO Corporation merged into ConocoPhillips Company in 2003. The Sand Wash oil shale leases were relinquished by ConocoPhillips on January 5, 2015.

Between 1970 and 1985, several Utah oil shale projects were started, many on SITLA lands, including one, Geokinetics, which actually produced shale oil. Brief descriptions of each project are included below and the map at the beginning of this report shows their general location.

Geokinetics, Inc. - Seep Ridge Project

In the early 1970s, Mike Lekas and his family developed a novel *in situ* technology on state oil shale leases that involved drilling vertical holes and blasting near surface oil shale. They would then horizontally retort the fractured shale in place, extracting the hydrocarbon gases and liquids from vertical holes. The technology was called LOFRECO (low front end capital). Geokinetics, with the assistance of Peter Kiewit Construction, the DOE, and a price guarantee from the U.S. Department of Defense (DoD), produced 117,438 barrels of shale oil between June 1979 and August 1984 (J. Blake, SITLA, 2015, personal communication), some of which went to the Caribou refinery in Salt Lake City. Refined products were



Geokinetics' Seep Ridge in situ shale oil recovery site, Uintah County, Utah, August 27, 1981. Photo credit: U.S. Geological Survey's Historical Photo Library

sent to the DoD for military testing (U.S. BLM, 2012; NRC, 1983).

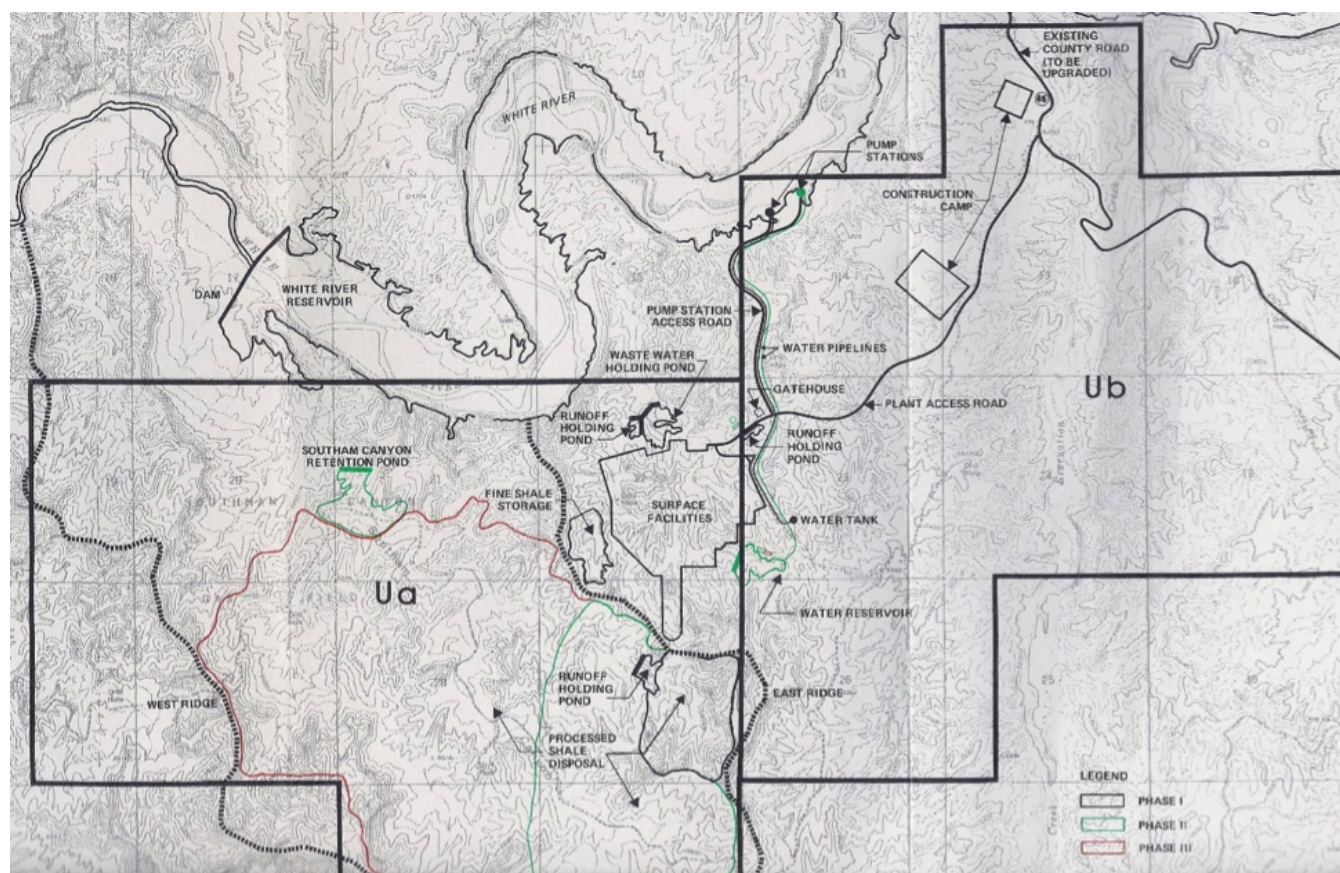
The Geokinetics Seep Ridge Project was closed down when funding for the Synthetic Fuels Corporation was cut off by the federal government in the mid-1980s. Geokinetics' oil shale production-lease (ML 24276A) was relinquished on January 22, 1991, and the lands were subsequently reclaimed (J. Blake, SITLA, 2015, personal communication).

White River Shale Project (WRSP)

Three major oil companies, Sohio, Phillips, and Sunoco, formed the White River Shale Corporation after successfully bidding on the adjoining Federal Prototype Leases Ua and Ub in 1974. Each lease covered 5120 acres,

BLM and other agencies as part of the permitting process (WRSP, 1981). After a lease suspension during which issues of land ownership were resolved, WRSP was given the approval to start construction in 1980.

The Prototype Leases were designed to encourage oil shale development and production and, as such, included a provision that money spent on the lease could be credited toward the installment payments required by the lease terms. While the WRSP was still working on the final plant design and retort details, they went ahead and began construction of the underground mine and certain surface facilities crucial to the project, such as the 25,000-square-foot main office/warehouse facility, the water treatment plant, the sewage treatment plant, and the electrical distribution center. A dog-leg, underground mine access ramp was built to reach the Mahogany



White River Shale Project overall site plan for development of Tracts Ua and Ub. Map credit: White River Shale Project, Detailed Development Plan, 1981

with the White River Mine essentially at the center of the adjoining leases. The project goal was to eventually produce 100,000 barrels of oil per day, employing underground room and pillar mining and surface retorts (Union B, Superior, and TOSCO II). The project did extensive drilling and resource studies, environmental baseline studies, and engineering during the 1970s, all aimed at preparing a Detailed Development Plan to submit to the

zone within the Parachute Creek Member of the Green River Formation, and a concrete-lined, 30-foot-diameter, 1058-foot-deep vertical ventilation/service mine shaft was sunk (Sokolosky, 1995). Mine development also included a 16-foot-diameter, 70-foot-deep exhaust shaft and a 5-foot-diameter, 450-foot-deep utility raise. Underground construction included the crusher station and a rock mechanics test room. It is estimated that

WRSP spent over \$25 million on the mine construction and over \$30 million on the surface facilities (Hawes, 1993). The project was shut down in late 1985 after the decline in oil prices and the federal government's abandonment of its various synfuel initiatives. In early 1986, the mine and surface facilities were placed in standby mode and transferred back to the BLM, along with the Ua and Ub leases.

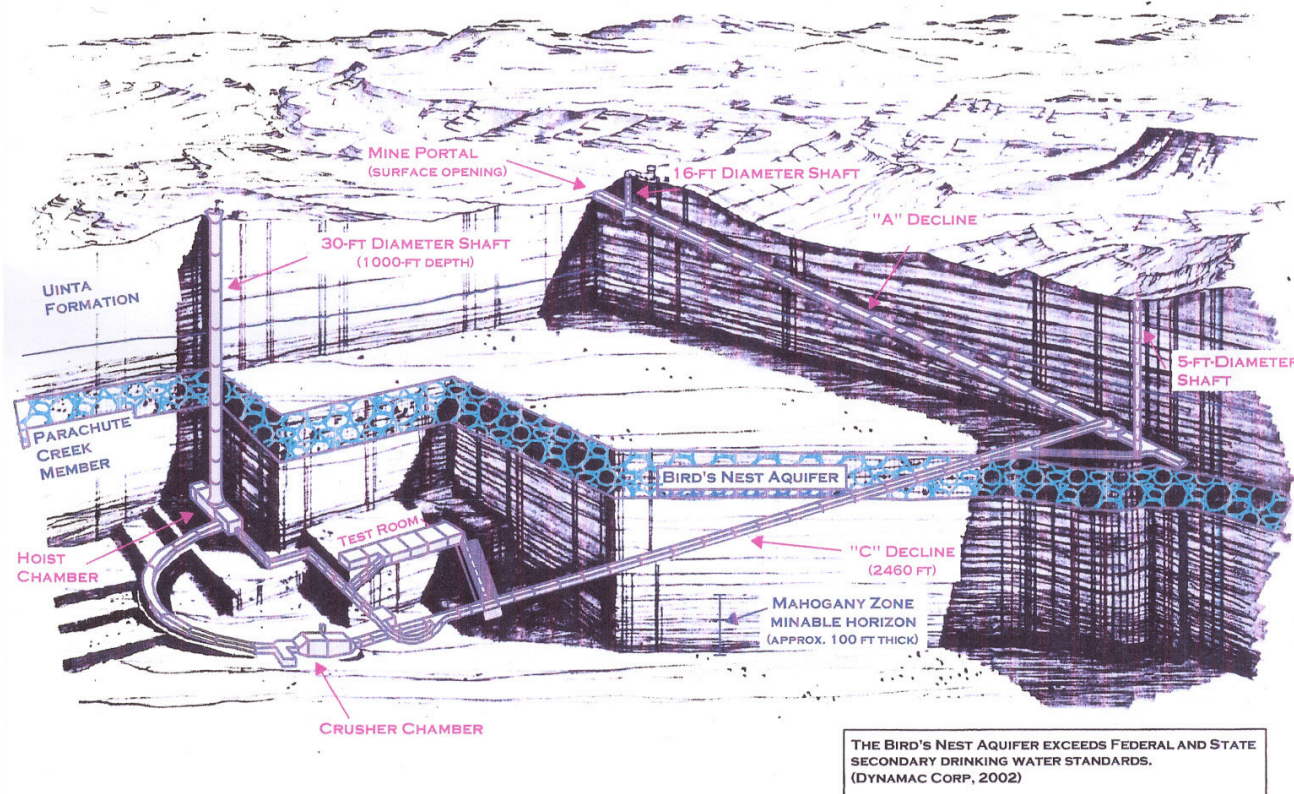
The BLM maintained the facilities at the site for eight years, hoping that the property and existing infrastructure would be leased by another oil shale company or somehow be put to beneficial use. The annual operating and maintenance costs were expensive and finally, in 1994, the BLM decided it needed to close the mine and put the property on standby. The pumps dewatering the minimal inflow of groundwater from the Birds Nest aquifer were shut-off and removed; a 10-foot-thick concrete bulkhead was installed to seal off the decline below the Birds Nest aquifer; concrete caps were placed on the top of the 16-foot ventilation exhaust shaft and the 5-foot utility raise; the decline portal entry was backfilled with rock and dirt; and the final measure was to secure the 30-foot shaft. A 2-foot-thick, reinforced concrete cap

was poured in-place over the top of the shaft, with a 6-inch steel vent pipe protruding vertically through the center of the cap. As a worker was welding a U-shaped steel elbow on the top of the vent pipe, apparently a flaming-hot weld fragment fell into the 30-foot shaft, which had accumulated sufficient methane gas, causing a tremendous explosion, which, unfortunately killed the worker. The concrete cap was blown off the shaft and chunks of concrete flew so far that pieces penetrated the metal roof of the office building hundreds of yards away. To avoid recurring problems with capping this shaft the BLM elected to lay chain-link-fence mats horizontally over the shaft and secure the shaft area with a perimeter fence, which is how it remains to this day.

Paraho-Ute Project

The Paraho Corporation, along with a group of sponsors, including Sohio, Cleveland-Cliffs, and the DOE, had completed the final design for a Paraho vertical retort sized to produce 10,000 barrels per day. The Paraho-Ute Project, involving most of the same companies, completed preliminary design for a 30,000-barrel-per-day plant, employing multiple Paraho retorts that would have

WHITE RIVER OIL SHALE UNDERGROUND MINE WORKINGS (3D CUT-AWAY VIEW)



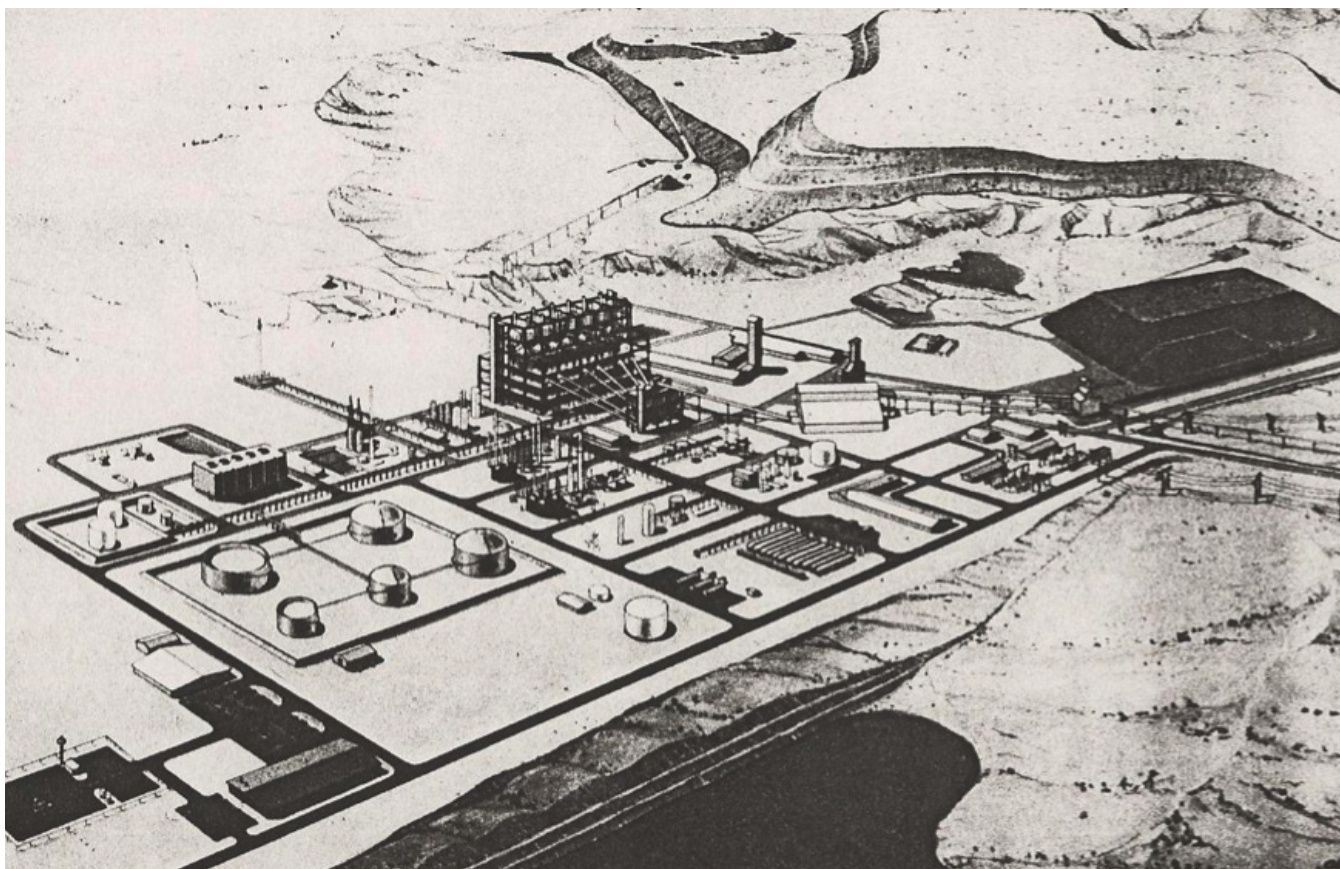
Cut-away drawing of the completed underground mine development work at the White River site. Top center is the portal entry for the dog-leg decline to convey oil shale from the crusher station below the Mahogany mining horizon. On the left is the 30-foot-diameter vertical ventilation shaft, 1058-feet deep. **Source:** Dynamac Corp., 2002



Current condition of the White River Mine Project site, abandoned in 1985. Office/warehouse building (25,000 square feet) in upper portion of photo; mine hoist in the middle; and lower right is the open 30-foot-diameter, 1058-foot-deep ventilation shaft fenced off for safety. This is on the BLM RD&D Site leased to Oil Shale Exploration Company (OSEC) in 2007; OSEC was purchased by Enfit American Oil Company in 2011. **Photo credit:** Michael D. Vanden Berg, Utah Geological Survey



The decline portal entry to the underground White River Mine. This area was backfilled with dirt as part of the BLM's mine closure program in 1994–1995. **Photo credit:** U.S. Bureau of Land Management



Drawing of TOSCO's proposed oil shale plant at Sand Wash, circa 1982. **Source:** G. Vawter, personal files, 2015

been built north of the White River and east of Bonanza, Utah. Oil shale ore would have been sourced from an underground room and pillar mine. The project was unsuccessful in securing funds from the Synthetic Fuels Corporation and construction was never started. The project was abandoned in 1983.

TOSCO Sand Wash Project

TOSCO acquired SITLA leases on over 8000 acres southwest of Vernal in the Sand Wash area. The company was planning a relatively deep underground mine (~2000 ft) with TOSCO retorts on the surface (see drawing on pg 11). The goal was to produce 50,000 barrels per day. Engineering design and permitting work had been started, but project planning was terminated in 1983. TOSCO was acquired by Phillips Petroleum, which later merged with Conoco to form ConocoPhillips. ConocoPhillips held the SITLA leases until January 2015 before finally surrendering them.

Chevron/Conoco Pilot Plant

These companies built a 350-ton/day Staged Turbulent Bed retort pilot plant at the Chevron refinery site in Salt Lake City. Shale for this research project came from Chevron's Red Point Mine near Debeque, Colorado. This program only operated for two years in the early 1980s.

Syntana-Utah Project

Quintana Minerals Corporation of Houston, along with Magic Circle Energy Corporation and others, held Utah state oil shale leases north of the White River, east of Bonanza, and together they were working on plans for an oil shale project. Engineering was underway and a draft environmental impact statement was being circulated when the project was halted in the early 1980s.

Western Oil Shale Corporation (WOSC)

WOSC, a Salt Lake City company, was active in the 1960s and 1970s. They acquired SITLA leases in the Magic Circle area from Texas American Oil Corporation by way of assignment (J. Blake, SITLA, 2015, personal communication). WOSC drilled several oil shale exploration core holes and published a quarterly magazine titled "Western Oil Shale" to promote oil shale development in the West. WOSC merged into Magic Circle Energy Corporation (MCEC), an Oklahoma company, in 1980, when MCEC took control of the SITLA oil shale leases in the area now identified as the Magic Circle Block.

Magic Circle Energy Corporation - Cottonwood Wash Project

Magic Circle Energy Corporation held a large block of Utah state oil shale leases west of Vernal and south of TOSCO's Sand Wash site (SITLA's Magic Circle Block). Magic Circle had a joint venture with Deseret Generation and Transmission Company, as well as others. They were unsuccessful with an application for funds from the

Synthetic Fuels Corporation and the project was discontinued in the early 1980s. The leases were relinquished in 1990.

Texaco and Raytheon

Texaco and Raytheon were doing pilot-scale field tests on in situ heating of oil shale with radio frequency equipment on Texaco's oil shale property in the Book Cliffs area of southern Uintah County. Technical reports on the pilot tests were written, but the companies did not make commercial project plans for the property. In order to reduce the costs for holding its Utah land position, Texaco donated the surface of its large oil shale property to the Rocky Mountain Elk Foundation (RMEF), retaining the mineral rights. Later, the RMEF transferred the surface rights to the Utah Division of Wildlife Resources.

Sohio and Cleveland-Cliffs

In 1968, Sohio and Cleveland-Cliffs together acquired a 75-year lease on two large blocks (Skyline I and Skyline II) of oil shale land owned by Skyline Oil Company, just south and east of the Ua and Ub tracts. Skyline Oil, under the leadership of Max D. Eliaason, had spent many years acquiring patented oil shale claims in the area. The acquired claims included those of General Mines Company, Watson Oil Company, the Koenigsmark group, and the Stringham family. Sohio and Cliffs had long-term plans to develop a commercial oil shale project on these lands. In 1985, after Sohio and partners abandoned the White River Shale Project, Cleveland-Cliffs' subsidiary Cliffs Synfuel Corp. purchased Sohio's interest in the Skyline leases and other properties. In 1994, Cliffs Synfuel purchased the underlying mineral rights from Skyline Oil Company, which had become part of Texas Eastern Petroleum and then Panhandle Eastern. Following these transactions, Cliffs Synfuel Corporation became one of the largest private oil shale land companies in the state of Utah. The author was president of Cliffs Synfuel during that period of time.

Gulf Oil Company

Gulf leased, with an option-to-buy, the large oil shale land position held by the Larson Family, which included patented and unpatented mining claims that the Larsons had assembled over decades. Gulf developed mining plans for two different projects on these lands. One of the mining plans provided for a surface mine in the Book Cliffs area of southern Uintah County and the other was for an underground mine south of the White River, near the Colorado border. After Gulf was acquired by Chevron, the company continued exploration drilling and other work on the unpatented claims for a number of years. Eventually, Chevron surrendered the leases and the Larsons resumed work on the unpatented mining claims.

The Larson Family

Frederick V. Larson from Grand Junction, Colorado, was involved in the pre-1920 oil shale staking activity

and began acquiring patented and unpatented oil shale claims after interest in oil shale ebbed in the 1920s. Besides acquiring interest in over 3000 acres of private land south of the White River, he held 156 of the pre-1920 unpatented oil shale mining claims that totaled over 25,000 acres. After his death, his son Frederick H. Larson managed the lands and filed for patent on the remaining unpatented claims in 1988 and 1989. After receiving the first half of the mineral entry certificate in 1992, the BLM challenged the validity of the claims. Frederick H. Larson passed away in 1995 and management of the lands passed to his son Frederick A. Larson. The Federal District Court in Washington, D.C., upheld the validity of the Larson unpatented claims in 2006. The Federal Justice Department challenged the ruling and it went to the U.S. Circuit Court of Appeals for Washington, D.C., which overturned the District Court ruling in early 2009. In late 2009, Larson petitioned for a hearing before the U.S. Supreme Court but was denied. Every attempt was made by Larson to get a favorable ruling on their patent applications but in the end the applications were denied and the Larsons had to surrender their rights to these pre-1920 unpatented claims.

The Larsons had also owned a large block of unpatented oil shale claims in the southern part of the Uinta Basin in the area of SITLA's Holliday Block. History of these Larson claims is mentioned earlier in the section on Utah's SITLA oil shale lands.

Colorado-Utah Oil Shale Company

The Colorado-Utah Oil Shale Company owns 960 acres of private oil shale lands near Evacuation Creek, south of the abandoned town of Watson, Utah. There is no record of development activity on these patented oil shale lands.

Utah-Colorado Oil Corporation

Utah-Colorado Oil Corporation owns 3870 acres of patented oil shale claims near the abandoned town of Dragon, Utah, on the Utah-Colorado state line. There is no record of any development activity on these lands.

Utah Shale Land & Minerals Corporation

Utah Shale Land & Minerals Corporation, now defunct, had owned 19,280 acres of patented oil shale claims along the oil shale outcrop area in southern Uintah County. The area adjoins the old Naval Oil Shale Reserve #2. The company drilled and evaluated the oil shale beds, did mining and project feasibility studies, but never built any facilities. The lands were sold and are now owned by Mustang Fuel Corporation out of Oklahoma City.

Uintah Oil Shales, Inc. and Uintah Oil Association

The owners of these two companies seem to be very similar. Uintah Oil Shales, Inc. owns about 2278 acres and Uintah Oil Association owns about 2038 acres; all lands are patented oil shale claims along the oil shale outcrop belt in southern Uintah County. Other than geo-

logic studies and a few drill holes, there is no evidence of development work on these lands.

Naval Oil Shale Reserve #2 (NOSR #2)

In 2001, Congress transferred this undeveloped oil shale resource to the Northern Ute Indian Tribe in exchange for lands near Moab, Utah, which the government wanted as a repository for uranium mill waste materials.

RECENT UTAH OIL SHALE ACTIVITIES: THE CURRENT BOOM

Between 1985 and 2005, there was little oil shale activity in Utah. However, growing concerns about the nation's dependence on imported oil resulted in the U.S. Congress passing the 2005 Energy Security Act. This Act dictated, among other things, that the DOE look at the potential for unconventional domestic fuels, and instructed the BLM to offer oil shale research leases and put together a commercial leasing program. The BLM solicited nominations for Research, Development, and Demonstration (RD&D) Leases and five were issued in 2007, four in Colorado and one in Utah. The Utah RD&D lease was issued to Oil Shale Exploration Company for a 160-acre area that encompassed the mine and surface facilities of the old White River Mine site that had been abandoned by the White River Shale Corporation in 1986.

Oil Shale Exploration Company (OSEC)

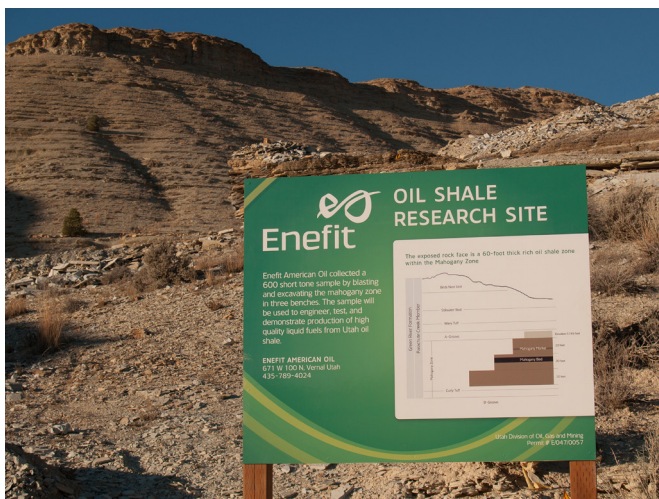
OSEC signed the RD&D lease with the BLM in 2007 and shortly thereafter bought Cliffs Synfuel Corporation, the Utah subsidiary of Cleveland-Cliffs Inc. As a result of the acquisition, OSEC controlled what many consider to be the best private oil shale land position in Utah. Those private lands, along with the RD&D lease of the White River Mine, put OSEC in a strong position to develop a commercial oil shale project. OSEC was joined by the Brazilian energy company Petrobras and the Japanese company Mitsui in plans to develop a 50,000-barrel-per-day Skyline Oil Shale Project, employing Petrobras' Petrosix retort technology that has been operating in Brazil for more than 20 years. OSEC and its partners did extensive drilling and geologic evaluations and prepared a commercial feasibility study for the project. In late 2010, Petrobras and Mitsui left the project and in 2011 OSEC was acquired by Enefit American Oil Company, the U.S. subsidiary of the national energy company of Estonia, Eesti Energia.

Enefit American Oil Company

Eesti Energia has been producing shale oil in Estonia for more than 30 years. In addition, Estonian companies have been burning oil shale for power generation for nearly 100 years. In 2012, Eesti Energia completed construction and commissioning of a new Enefit 280 oil shale retort at its Narva, Estonia, power plant. This retort is a horizontal rotary kiln followed by combustion of the residual carbon on the spent shale. A portion of the hot



Enefit's three-bench bulk sample site, exposing the proposed 60-foot-thick mining horizon within the Mahogany oil shale zone. First samples were taken in 2012. Uintah County Road 4180 is on the right. **Photo credit:** M. Vanden Berg, Utah Geological Survey



Enefit's Oil Shale Research Site where the bulk sample box cut exposes the proposed 60-foot-thick mining zone within the Mahogany oil shale horizon. **Photo credit:** M. Vanden Berg, Utah Geological Survey

shale ash is then mixed with raw shale coming into the retort to serve as the heat transfer media for pyrolysis.

In 2011, Enefit American Oil Company, a wholly-owned subsidiary of Eesti Energia, acquired OSEC and continued plans for a 50,000-barrel-per-day oil shale facility on the Skyline private property, southeast of the White River Mine, using the Enefit 280 retort technology. Since 2011, Enefit has been doing resource characterization, environmental baseline studies, mine planning, pilot plant tests, and commercial feasibility studies. They are currently working with the BLM on an environmental impact statement for a utility corridor across BLM lands.



Aerial photo of Red Leaf's pilot plant test site, 2009. **Photo credit:** Red Leaf Resources (used with permission)

Enefit is planning a surface mining operation, employing truck-shovel and dragline equipment. Spent shale will be placed back into the mine pit. In 2012, in order to collect a representative bulk sample of oil shale for pilot tests, Enefit opened a 60-foot-high box cut, using three 20-foot benches. The 60-foot-thick zone represents the proposed mining horizon within the Mahogany oil shale zone. The average grade for the 60-foot zone is between 25 and 27 gallons of oil per ton of rock. The box cut is on the west side of Uintah County Road 4180, about 10 miles south of Bonanza. Enefit posted a sign at the location, calling it the Enefit Oil Shale Research Site.

Red Leaf Resources

Red Leaf Resources has leased oil shale lands from SITLA and plans to use the EcoShale In-Capsule retorting technology. The EcoShale retort is a modified *in situ* method where crushed shale is placed in a carefully constructed in-ground, bentonite-lined capsule and heated indirectly with hot gases passing through horizontal pipes embedded in the crushed shale. A pilot test of the technology was successfully constructed and completed in 2009 and the company is currently (as of 2015) building a near-commercial-scale demonstration retort called the Early Production System (EPS). The EPS is a 5/8-scale of the commercial design, measuring 700 feet long, 350 feet wide, and 150 feet deep, covering an eight-acre area. The EPS could produce as much as 360,000 barrels of shale oil. EPS construction started in late 2014; however, with the current low price of oil, the company has slowed construction, and the retort heat-up is now planned for late 2016 (J. Hartley, Red Leaf, 2015, personal communication). Besides a group of private investors, Total S.A., the French oil company, is a major partner in the project and provides technical oversight.

Tomco Energy

Tomco has leases on over 2900 acres of SITLA oil shale land in southern Uintah County, and they have a license

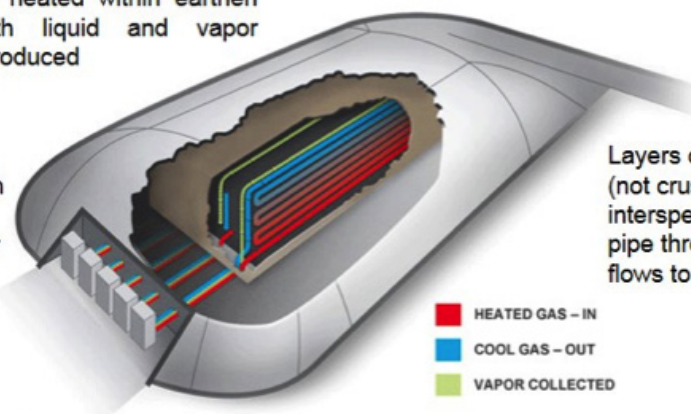


EcoShale™ In-Capsule Technology

Oil shale is slowly heated within earthen capsule until both liquid and vapor hydrocarbons are produced

Capsule is lined with EPA-recognized impermeable barrier

Gravity-aided collection pan on the bottom gathers prompt liquids, vented collection pipes along roof capture hydrocarbon vapors



Layers of rubble-sized (not crushed) shale are interspersed with layers of pipe through which hot gas flows to heat capsule

Slow roasting the oil shale creates a higher-quality oil product

Schematic of Red Leaf's EcoShale In-Capsule Technology. Source: Red Leaf Resources (used with permission)

to use Red Leaf's EcoShale technology. Exploratory drilling and resource evaluation have been completed, as well as a commercial feasibility study. A mining permit application on 1280 acres was submitted in early 2014. Construction could start in 2015 if the company secures the required permits.

Enshale, Inc.

Enshale, a subsidiary of Bullion Monarch Mining, leased a number of SITLA oil shale tracts near Bonanza and built a small pilot plant just south of Naples, Utah. The retort design involved a horizontal rotary kiln. Pilot plant tests were carried out for several years using about 1000 tons



The Enshale horizontal rotary kiln pilot plant near Naples, Utah, 2014. Photo credit: G. Aho, Sage Geotech Inc.



The 80-foot tall Oil-Tech pilot plant, south of the Stanton Road, east of Bonanza, Utah. This retort produced small quantities of shale oil from White River Mine oil shale. The plant was built in the early 2000s and was still on the site in 2014, owned by Ambre Energy. Photo credit: M. Vanden Berg, Utah Geological Survey

of oil shale obtained from the White River Mine stockpile. Bullion Monarch was acquired by Eurasian Minerals in 2012 and oil shale research was discontinued. Eurasian was seeking a buyer for the SITLA leases and the pilot plant facility. The SITLA leases were cancelled for non-payment on April 1, 2013 (J. Blake, SITLA, 2015, personal communication). In late February 2015, the author noted that the pilot plant had been dismantled, the buildings removed, and the property was for sale.

Ambre Energy/Oil-Tech/Millennium Synfuels

Oil-Tech Inc., led by Byron Merrill of Vernal, developed the patented Oil-Tech oil shale retorting technology, a vertical shaft retort that employs vertically-spaced horizontal electrical heating elements. In the early 2000s, Oil-Tech built and operated a pilot plant on a SITLA industrial lease east of Bonanza, Utah. Shale for the pilot plant was obtained from the stockpile at the White River Mine. Ambre Energy Limited, an Australian coal mining and export company with a United States subsidiary, Ambre Energy North America, bought an interest in Oil-Tech Inc. in 2006, and together the companies formed Millennium Synfuels to develop a Utah oil shale project. Eventually, Ambre fully acquired Oil-Tech and by 2010 controlled over 34,000 acres of SITLA oil shale leases (DOE, 2010). After drilling a number of exploration holes and conducting development studies, Ambre put the leases and the pilot plant up for sale in 2013. In 2014, Red Leaf acquired most of the Ambre SITLA leases. Ambre reported that if they could not find a buyer, they would be forced to dismantle the Oil-Tech pilot plant. In February 2015, the author noted that the pilot plant was still intact on the property.

Combustion Resources

Based in Provo, Utah, Combustion Resources developed and tested an oil shale retort that involved indirectly heating oil shale in a rotary kiln. The heat was applied to the outer shell of the retort by burning natural gas or hydrogen. The hydrogen would be generated in a separate coal gasification unit. The company received grants from the DOE in the mid-2000s and was conducting bench and pilot tests on shale obtained from the White River Mine.

UTAH OIL SHALE HISTORY SUMMARY

For over 100 years, the dream of developing a commercial oil shale project in Utah has eluded prospectors, investors, and even major oil companies. Through the years, episodes of activity occurred whenever the world supply of oil seemed threatened and the price of crude increased. When oil prices decreased and the scare of shortages receded, oil shale activity would die off and projects would be shelved.

Utah's oil shale resource is enormous and the potential for developing a very significant industry in the state is undeniable. As the demand for liquid fuel continues to grow, technologies should evolve that will make production of shale oil commercially competitive with

conventional crude oil. A commercial oil shale industry would create many high-paying, long-term employment opportunities, generate tax revenues for state and local governments, and help the nation become less dependent on foreign sources of oil.

In Utah, significant quantities of shale oil were produced by Geokinetics in the 1980s and by Red Leaf Resources in 2009. Red Leaf is currently building the first near-commercial-scale module of the EcoShale retort, which should be producing shale oil by late 2016. If this first module is successful, it could soon lead to construction of a 10,000-barrel-per-day commercial project in southern Uintah County. In addition, if the Red Leaf commercial module project proves successful, a similar project at Tomco's lease could be close behind.

Enefit American Oil could be the largest Utah shale oil producer within 20 years, if their plans for a 50,000-barrel-per-day plant stay on track. The company had announced a plan to begin Phase 1 construction (25,000 barrels per day) in 2017, although it appears from recent statements that permitting could set that back.

In February 2015, as these Utah shale projects finally advance towards commercial production without federal financial assistance, it is ironic that once again we are seeing a glut of oil in the world supply chain and the prices have dropped 50% in the past six months. New technologies, particularly horizontal drilling and hydraulic fracturing ("fracking"), have resulted in extensive tight crude oil production from shales such as the Bakken, Eagle Ford, and Niobrara.

The author believes in the technical and economic viability of oil shale and hopes that Utah oil shale projects "stay the course." However, oil shale is capital intensive and lenders need to be convinced that the production of Utah oil shale is commercially viable before they back the financing of these projects. The next few years will be critical as to whether we finally see a breakthrough and have sustained shale oil production, or whether we go into another bust period for Utah oil shale.

This paper was meant to give a general historical account of the oil shale industry in the western United States with special emphasis on Utah. Those interested in more detailed accounts are encouraged to read the references cited below.

ACKNOWLEDGMENTS

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