UTAH MINING 2017

by Taylor Boden, Ken Krahulec, Michael Vanden Berg, and Andrew Rupke

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Cover photo: *Historical ore chute of the Pratt manganese mine in the Drum Mountains mining district, Juab County, view toward the north.*

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2017 UTAH MINING INDUSTRY SUMMARY

The estimated value of Utah's extractive resource production in 2017 totaled $5.8 billion, including both crude oil and natural gas production as well as all mining activities (figure 1). Utah's diverse mining industry accounted for $3.3 billion (57%) of total extractive resource production, an increase of $213 million (6.9%) from 2016, but down 37% from peak values reached in 2011 ($5.3 billion). Mining activities in Utah currently produce base metals, precious metals, industrial minerals, and coal (figure 2). Base metal production contributed $1.4 billion and includes copper, magnesium, beryllium, and molybdenum; copper accounts for 70% ($951 million) of total base metal production value (figure 3). Precious metals produced in Utah include only gold and silver, and 2017 production was valued at $261 million (figure 3). Both base and precious metal values increased from 2016 to 2017, up 11% and 15%, respectively. Utah also produced several industrial mineral commodities including sand and gravel, crushed stone, salt, potash, cement, lime, phosphate, gilsonite, clays, gypsum, and others (figure 2). The estimated value of industrial mineral production in 2017 reached $1.2 billion, a 5% increase over 2016 (figure 3). The most valuable industrial mineral group in 2017, estimated at $410 million, was the brine- and evaporite-derived commodities that included potash, salt, and magnesium chloride. In contrast to other minable commodities, the value of Utah coal production decreased in 2017 to $493 million, from $509 million in 2016 (figure 3). Historically, companies also produced significant quantities of iron, uranium, and vanadium in Utah, but production of these commodities has been suspended due to low prices. However, Energy Fuels Resources continues to operate its White Mesa uranium mill in San Juan County, mostly processing stockpiled ore and ore from Arizona. Notably, Utah remains the only state to produce magnesium metal, beryllium concentrate, potassium sulfate, and gilsonite; of these mineral commodities, magnesium, beryllium, and potash (includes potassium sulfate) are included on the U.S. Department of the Interior's 2018 critical mineral list.

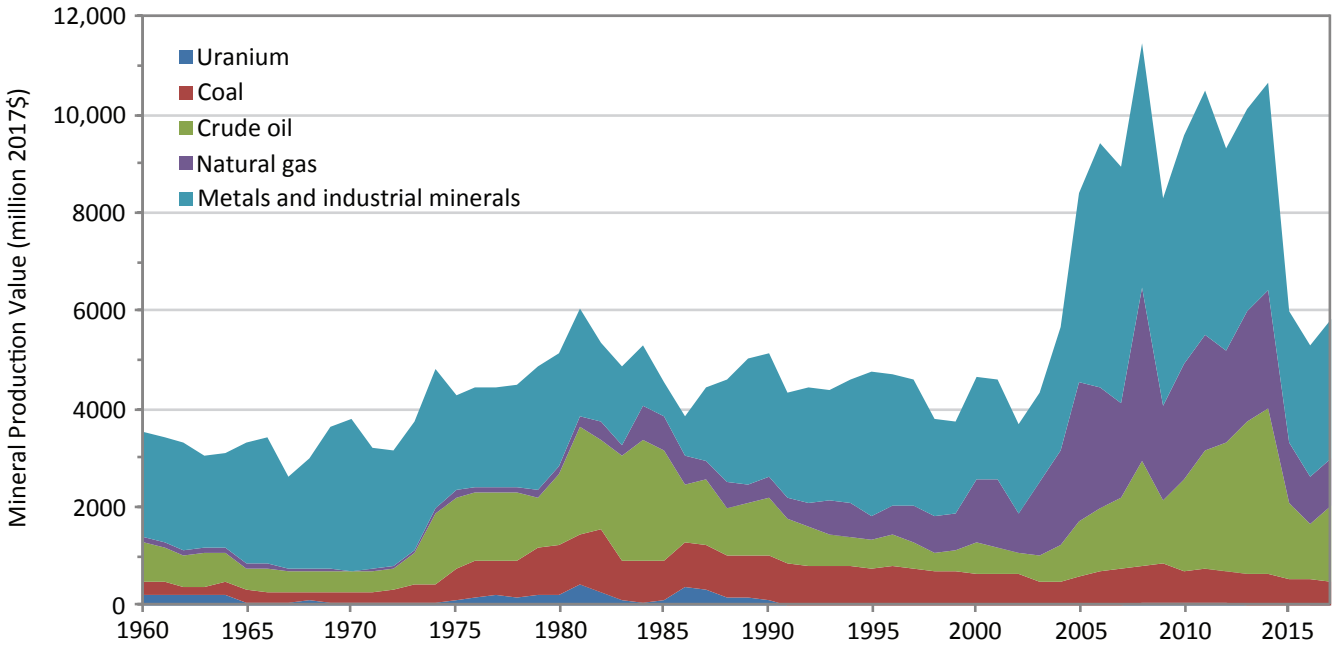
For 2017, the U.S. Geological Survey (USGS) ranked Utah as 8th nationally for production of nonfuel minerals, which includes metals and industrial minerals (table 1). The USGS estimated Utah's nonfuel mineral production value at $2.6 billion (compared to the Utah Geological Survey estimate of $2.8 billion), which accounts for 3.5% of the U.S. total (USGS, 2018a). Utah has ranked among the top ten for the past decade. Utah ranked as the 11th largest coal producer out of 24 coal-producing states and accounted for 1.9% of total U.S. coal production (U.S. EIA, 2018). In the 2017 Fraser Institute annual survey of mining companies, Utah was ranked as the 15th most favorable state/nation out of 91 international jurisdictions (89th percentile) in terms of overall investment attractiveness with regard to mining (table 1) (Stedman and Green, 2018). The investment attractiveness index is a combination of a region's geologic favorability along with favorable government policies toward exploration and development.

In 2017, the minerals regulatory program within the Utah Division of Oil, Gas and Mining (DOGM) approved 11 small mine permits and nine exploration permits, but no new large mine permits (table 1). The small mine permits included five for riprap, stone, and similar materials, and one each for gilsonite, calcium carbonate, diatomaceous earth, septarian nodules, selenite gypsum, and humic shale. The exploration permits were for precious metals (4), calcium carbonate (2), and one each for oil sand, gilsonite, and gemstones (Paul Baker, DOGM, written communication, June 2018).

The Utah School and Institutional Trust Lands Administration (SITLA), which manages about 4.4 million acres of state-owned lands in Utah, issued new mineral leases on 57 mineral tracts in 2017, up 8% from 2016 (table 1). These leases were issued for the following commodities: metalliferous minerals (28), sand and gravel (12), building stone (7), industrial sands (2), bituminous (or oil) sand (2), gemstone/fossil (2), and one each for potash, phosphate, geothermal, and humic shale (Jerry Mansfield, SITLA, written communication, June 2018).

In 2016 and 2017, there was a dramatic increase in the number of new unpatented mining claims filed on federal lands in Utah, despite only modest increases in most metal prices. The exception was the sharp rise in lithium prices, which resulted in several new claims targeting lithium prospects. In addition, construction began on a large lithium ion battery factory about 20 miles east of Reno, Nevada, which led to exploration for a local source. In 2017, San Juan (lithium), Beaver (copper and gold), Tooele (lithium, gold, and copper), and Grand (lithium) Counties were the most active, each recording over 500 newly filed claims. At the end of 2017, the U.S. Bureau of Land Management (BLM) reported a total of 21,936 active unpatented mining claims in Utah, up 2.0% from 2016 (table 1) (Opie Abeyta, Utah BLM, written communication, June 2018).

The Utah mining industry made a significant contribution to the state tax base during 2017 (figure 4). The metal, indus-



Source: Utah Geological Survey; U.S. Geological Survey; Utah Division of Oil, Gas and Mining; U.S. Energy Information Administration; Utah Tax Commission
Note: 2018 data estimated

Figure 1. *Annual value of Utah energy and mineral production, inflation adjusted to 2017 dollars, 1960–2018.*

trial mineral (non-metal), sand and gravel, and coal mining industries paid over $66 million in property taxes during 2017 (down 9% from 2016) and nearly $7 million in mining-related severance taxes (down 2% from 2016). All extractive industries, including oil and gas, paid over $75 million in federal Mineral Lease disbursements. Only about 1.0% of Utah's gross domestic product came from the mining industry in 2016, 1.6% if oil and gas are included (2017 numbers are not yet available). Long-term mining employment tends to mirror commodity price swings, but in contrast, average mining salaries have steadily increased over the same time frame (figure 5). More recent trends show employment decreasing since 2012 and wages stagnating since 2015.

BASE AND PRECIOUS METALS

Production and Values

Utah's base metal production value totaled $1.4 billion in 2017, an 11% increase from 2016, mainly due to higher copper prices and significant increases in byproduct molybdenum, gold, and silver output by Kennecott Utah Copper (KUC) (figure 3). The production value of precious metals reached $261 million in 2017, an increase of 15% from 2016, mainly due to higher gold and silver production by KUC (figure 3). Figure 6 shows production and value of select metals since 2000.

KUC's Bingham Canyon mine, located about 20 miles southwest of Salt Lake City in the Oquirrh Mountains, produces all of Utah's molybdenum, gold, and silver and nearly all its copper (figure 2). The combined value of metals produced by KUC in 2017 is estimated at $1.3 billion, a 26% increase from 2016.

Utah is the sole U.S. producer of both magnesium and beryllium. Utah has produced these metals for the past several decades; magnesium production began in 1972 and beryllium in 1969. Magnesium production has increased significantly over the past couple of decades while beryllium production has fluctuated but it has remained in the same range since the 1970s.

Copper

The 2017 value of copper produced in Utah reached $951 million, a 22% increase from 2016 primarily due to increasing copper prices (figure 6). The KUC Bingham Canyon open pit porphyry copper-gold-molybdenum mine produced 164,000 short tons (st) of copper in 2017, which is over 98% of Utah's total copper production, but 4000 st less than 2016 (Rio Tinto, 2018). The 2017 average copper price increased 27%, from $2.25/lb in 2016 to $2.85/lb in 2017 (USGS, 2018b).

Lisbon Valley Mining and Tamra Mining (formally CS Mining) also produced minor amounts of copper during 2017 (figure 2). Lisbon Valley Mining operates a sediment-hosted copper mine and solvent extraction-electrowinning (SX-EW) processing facility about 30 miles southeast of Moab in San Juan County. They produced about 2670 st of copper in 2017, a decrease from their 2016 production. Tamra Mining's Rocky Range copper skarn production was also down in 2017 (specific numbers are unavailable). Tamra completed construction

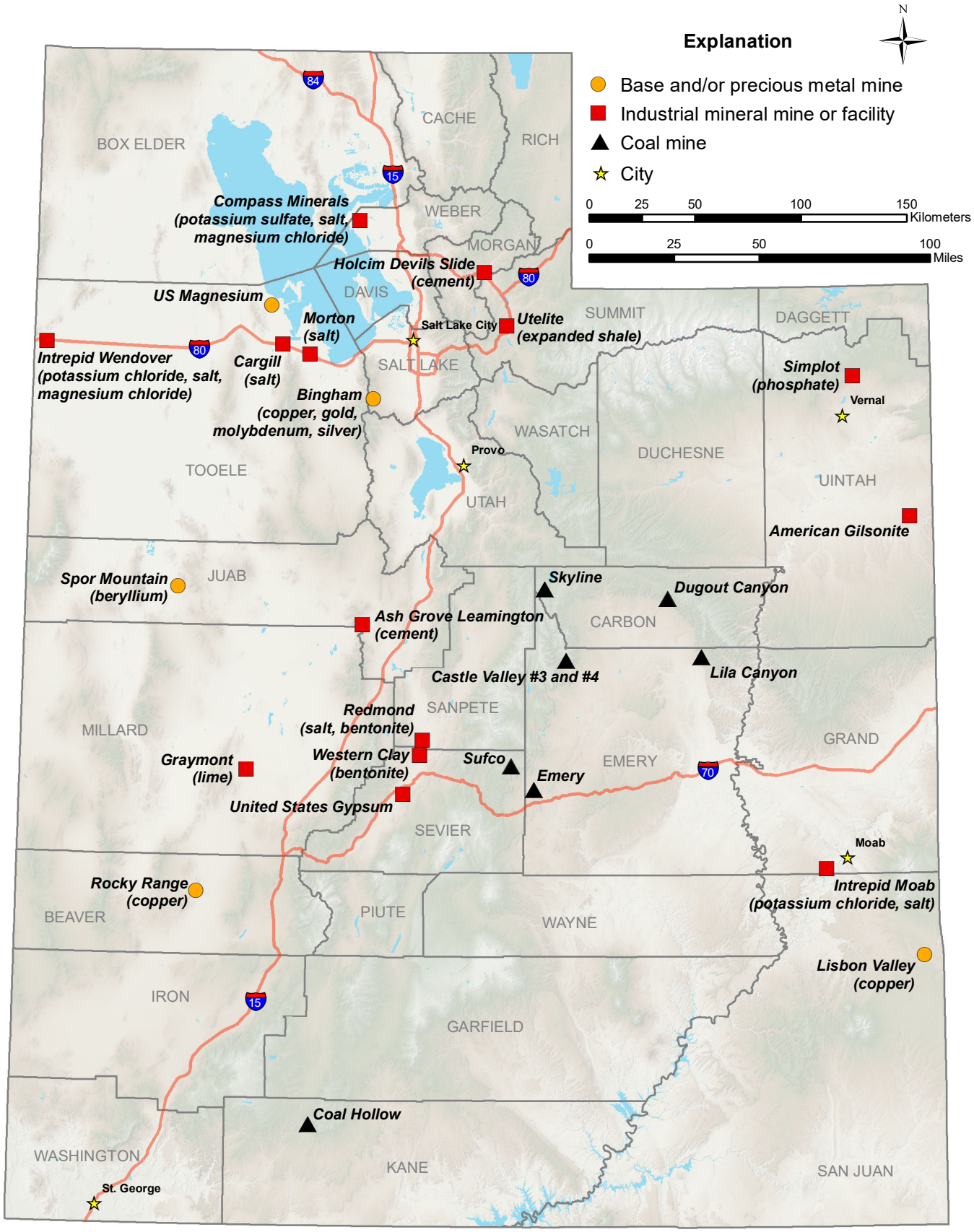


Figure 2. *Select base and precious metal, industrial mineral, and coal production locations in Utah.*

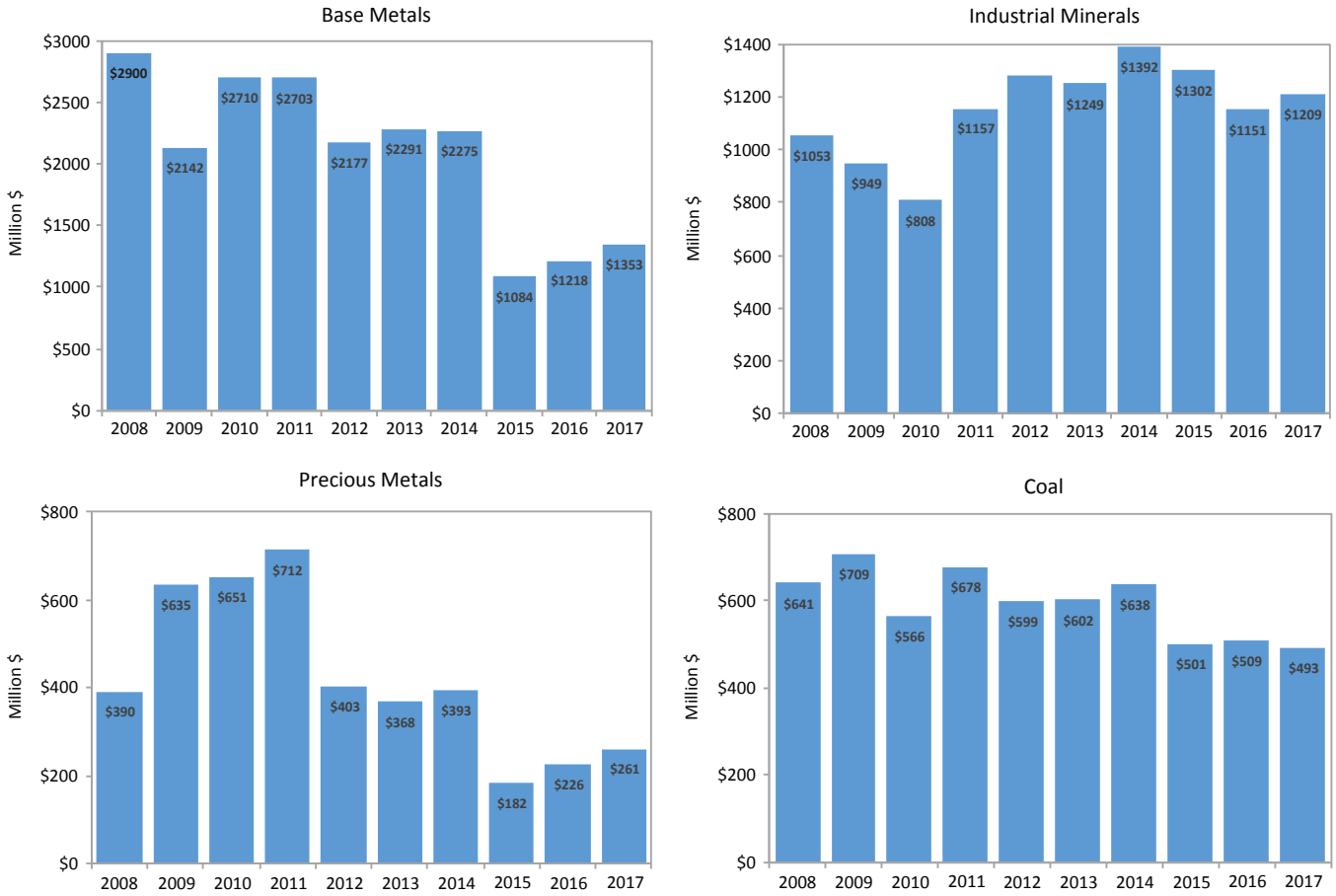


Figure 3. *Annual value of Utah mineral production in nominal dollars, 2008-2017. Source: Utah Geological Survey.*

of a new SX-EW plant early in 2016, which is now the primary metallurgical source for their copper production.

Copper is an internationally traded commodity and its price is determined by the world metal exchanges. Copper is combined with a number of metals to create alloys for a wide variety of applications and is used to produce a wide range of products including electrical wiring, electronic components, and pipe for plumbing, refrigeration, and heating systems (USGS, 2018b).

Magnesium

US Magnesium is the only facility producing magnesium metal from a primary source in the United States. The facility is located on the southwestern shore of Great Salt Lake about 60 miles west of Salt Lake City in Tooele County (figure 2). Magnesium chloride concentrate is produced from Great Salt Lake brines through evaporation and ultimately converted to magnesium metal by an electrolytic process. The annual magnesium production capacity at the US Magnesium plant is approximately 75,000 st (specific data on production is kept confidential by the company). The price for magnesium metal remained largely unchanged from 2016, averaging $2.15/lb in 2017 (USGS, 2018b). Magnesium was the second largest contributor to Utah's base metal value in 2017.

Significant quantities of US Magnesium's production had been used by the nearby Allegheny Technologies facility to produce titanium sponge. However, this plant was idled at the end of 2016 due to unfavorable market conditions. The idling of this plant significantly reduced magnesium demand in 2017. Magnesium is also used as a constituent of aluminum-based alloys, in castings and wrought products, in the desulfurization of iron and steel, and other minor uses (USGS, 2018b). Lithium, which is also concentrated with magnesium in the US Magnesium solar evaporation ponds system, has been considered as a possible future byproduct from the operation (Tripp, 2009).

Molybdenum

Utah molybdenum production in 2017 came solely from the KUC Bingham Canyon mine and was recovered as a byproduct from the copper operation. Approximately 5500 st of molybdenum was produced in 2017, a 79% increase from 2016, due primarily to a significant increase in tons mined (figure 6) (Rio Tinto, 2018). The average price of molybdenum also increased in 2017 by 25% to $8.16/lb (USGS, 2018b). At the 2017 average price, Utah molybdenum production had an estimated value of $90 million (figure 6), a 123% increase from 2016, reflecting the large increase in production and price. This valuation makes molybdenum Utah's third most valuable base metal produced in 2017.

Table 1. *Utah mining rankings and statistics.*

Utah mining ranking or statistic	2013	2014	2015	2016	2017
USGS[1] rank of U.S. nonfuel mineral production value (metals and industrial minerals)	7th	5th	8th	10th	8th
Fraser Institute annual survey of mining companies (favorability of mining jurisdiction)	15th of 112	14th of 122	9th of 109	11th of 104	15th of 91
U.S. EIA[2] rank for coal production by state	14th	13th	14th	10th	11th
New DOGM[3] approved large mine permits	4	2	2	0	0
New DOGM approved small mine permits	13	11	12	7	11
New DOGM approved exploration permits	9	14	17	11	9
SITLA[4] mineral leases issued	62	56	32	53	57
New BLM[5] mining claims filed	2360	3107	975	5366	5709
Total BLM mining claims (end of year)	19,487	19,770	18,520	21,497	21,936

[1]U.S. Geological Survey
[2]U.S. Energy Information Administration
[3]Utah Division of Oil, Gas and Mining
[4]Utah School and Institutional Trust Lands Administration
[5]U.S. Bureau of Land management

Molybdenum is primarily (87% of consumption) used in the production of stronger and more corrosion-resistant ferro-alloys (USGS, 2018b). These products are mainly used by petroleum and petrochemical operations, and consequently, molybdenum prices are strongly affected by the economic health of these industries.

Beryllium

Utah remains the United States' sole producer of beryllium ore and the largest producer in the world. Materion Natural Resources mines the mineral bertrandite [$Be_4Si_2O_7(OH)_2$] from the Spor Mountain area about 42 miles northwest of Delta in Juab County and operates a mill 11 miles north of Delta in Millard County (figure 2). Bertrandite ore and imported beryl are processed at the mill into beryllium hydroxide. Materion's parent company, Materion Corporation, operates a refinery and finishing plant in Ohio where the beryllium hydroxide concentrate is shipped and converted to beryllium-copper master alloy, beryllium metal, and beryllium oxide (USGS, 2018b). About 58,000 st of bertrandite ore was mined in 2017 from the Topaz mine at Spor Mountain, which translates into about 296,000 lbs of pure beryllium metal. The average price of beryllium in 2017 was $286/lb, 24% higher than 2016, resulting in a value of about $85 million (USGS, 2018b). Beryllium was Utah's fourth most valuable base metal in 2017.

Beryllium is a specialty metal primarily used in alloys and specifically in copper-beryllium high-conductivity alloy. Beryllium is used in telecommunications, consumer electronics, defense-related applications, industrial components, commercial aerospace applications, appliances, automotive electronics, energy applications, and medical devices. Because it is difficult to substitute other minerals for beryllium in some vital defense-related applications, beryllium is considered a critical mineral.

Gold

KUC Bingham Canyon mine produced 177,900 troy ounces (oz) of gold in 2017, a 15% increase from 2016 (figure 6). The Bingham Canyon mine is essentially Utah's only gold producer and it is recovered as a byproduct of copper mining (Rio Tinto, 2018). The average gold price in 2017 was $1260/troy oz, a slight increase from the 2016 average price (USGS, 2018b), making Utah's 2017 production worth $224 million, 16% more than the 2016 valuation (figure 6). Minor quantities of gold may have been produced by other small Utah mines, but this production is inconsistently reported and would not have a noteworthy impact on the total amount or value of gold produced in Utah.

Gold is an internationally traded precious metal used primarily for jewelry, coinage, bullion for monetary purposes, and to a lesser extent a variety of industrial and electronic applications. Because of its monetary uses, the price of gold fluctuates due to international tensions, financial upheaval, or variable inflation.

Silver

All of Utah's silver production in 2017 came from the KUC Bingham Canyon mine and was recovered as a byproduct of copper mining. Silver production in 2017 totaled 2,156,000

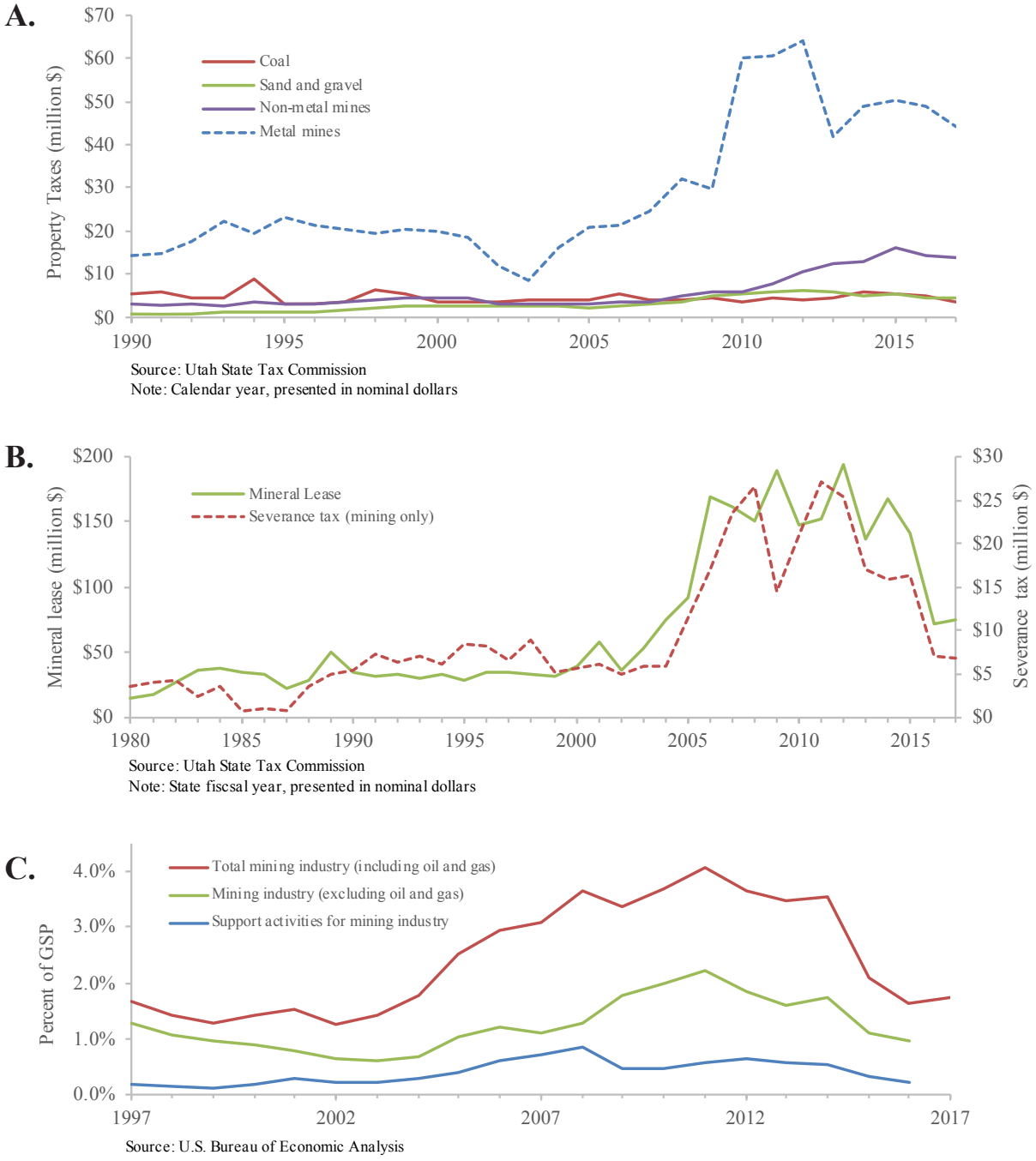


Figure 4. *Utah mining economic indicators.* ***A.*** *Property taxes charged against the mining industry, 1990–2017.* ***B.*** *Mineral lease and severance taxes on mining industry, 1980–2017.* ***C.*** *Percentage of Utah's gross state product from mining-related activities, 1997–2017.*

troy oz (Rio Tinto, 2018), an 11% increase from 2016, and the average silver price was $17.20/troy oz, a slight increase from the 2016 average price (figure 6) (USGS, 2018b). Utah's 2017 silver production had a value of $37 million, 11% more than the 2016 valuation (figure 6).

Silver is part precious metal and part industrial metal. Like gold, it is used for jewelry and coinage, but it is also heavily used for electronics, photography, and a wide variety of other industrial applications. Silver prices are determined by the world marketplace.

Exploration and Development Activity

The information in this section is largely compiled from a UGS annual industry survey of mine operators as well as mining company websites, press releases, and personal communications with government and operations staff. Exploration and development information was also obtained from the Utah DOGM website (2018). The mining districts that experienced exploration interest in 2017 are shown on figure 7 and summarized in table 2. Major district developments are summarized below.

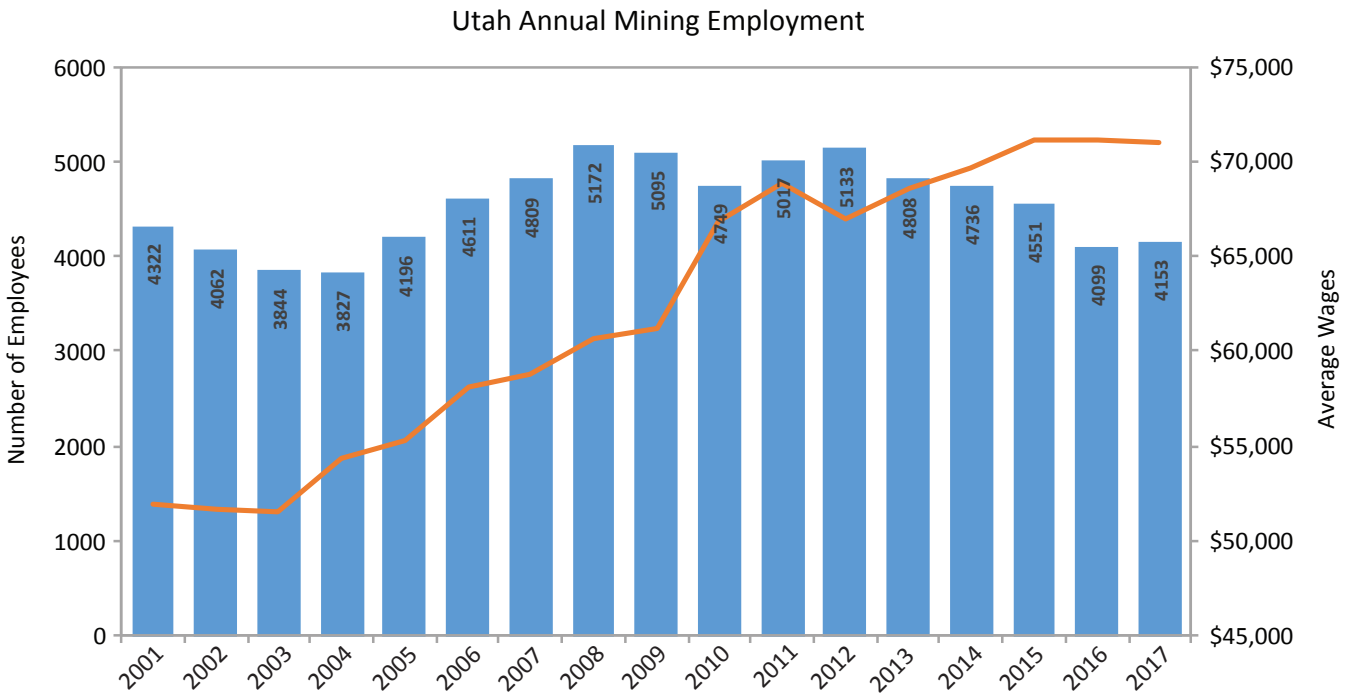


Figure 5. *Average annual mining employment and salaries in Utah. Includes metal, industrial mineral, and coal mines and facilities; excludes oil and gas. Source: Utah Department of Workforce Services (2018).*

Mineral exploration and development generally rises and falls with commodity prices. Metal prices bottomed out in 2015–16 and rebounded only modestly in 2017. The mining industry is in a period of guarded optimism, as prices remained too low to encourage robust new exploration and development.

Low metal prices have caused exploration activity to shift focus from riskier greenfield work to more prospective brownfield exploration near current or recently active operations. Another sign of the current risk-averse attitudes in the industry is the proliferation of joint ventures to spread the monetary risk. Metallic mineral exploration and development activity in Utah improved slowly throughout 2017. Interest in battery metals such as lithium, cobalt, vanadium, and tin has increased. Metal price forecasts generally predict modestly improving prices in the near term (2018–19), which could result in a future increase in exploration, development, and production.

Bingham District

Bingham is the most productive mining district in the United States (Krahulec, 2015), having a 2017 gross revenue of $1.4 billion (Rio Tinto, 2018). The mine is developed on a giant, Eocene-age (~38 Ma) porphyry copper-gold-molybdenum deposit. The Bingham Canyon's open pit mine 2017 production ranks it as the second largest copper producer in the United States. The mine, in production since 1903, became the world's first open pit porphyry copper mine in 1906 and is currently about 2.5 miles in diameter and 3830 feet deep. The Bingham Canyon open pit was designated a National Historic Landmark in 1966.

The massive Manefay pit-wall failures at the Bingham Canyon mine in April 2013 changed the face of the mine (Pankow and others, 2014; Krahulec, 2016). The slide debris has been removed from the pit, but complete recovery is not expected until late 2018. Nonetheless, Bingham's production rebounded significantly in both 2016 and 2017 and this recovery is expected to continue in 2018 and 2019.

Bingham is currently developing ore on the south side of the open pit, termed the south wall pushback (SPB). The SPB will allow development of roughly 700 million st of ore and move the wall of the pit about 1000 feet farther south and the pit bottom 300 feet deeper. This reserve will extend the mine life through 2027. The open pit has proven and probable reserves of 710 million tons at 0.43% copper, 0.17 ppm gold, 0.033% molybdenum, and 2.09 ppm silver (Rio Tinto, 2018). In addition, the North Rim skarn has measured, indicated, and inferred resources of 22 million tons at 3.65% copper, 1.62 ppm gold, and 21 ppm silver (Rio Tinto, 2018).

Less copper production from the pit in recent years left the KUC smelter at Magna with excess capacity, which allowed for toll smelting of compatible outside copper concentrates. The smelter processed 177,500 st of outside concentrates in 2017 (Rio Tinto, 2018). Kennecott Exploration Company has also continued their Bingham orbit exploration in the Oquirrh Mountains in 2017 completing 9622 feet of core drilling.

Lisbon Valley District

Lisbon Valley Mining operates a sediment-hosted, open pit, heap leach, SX-EW copper operation situated in the Lisbon

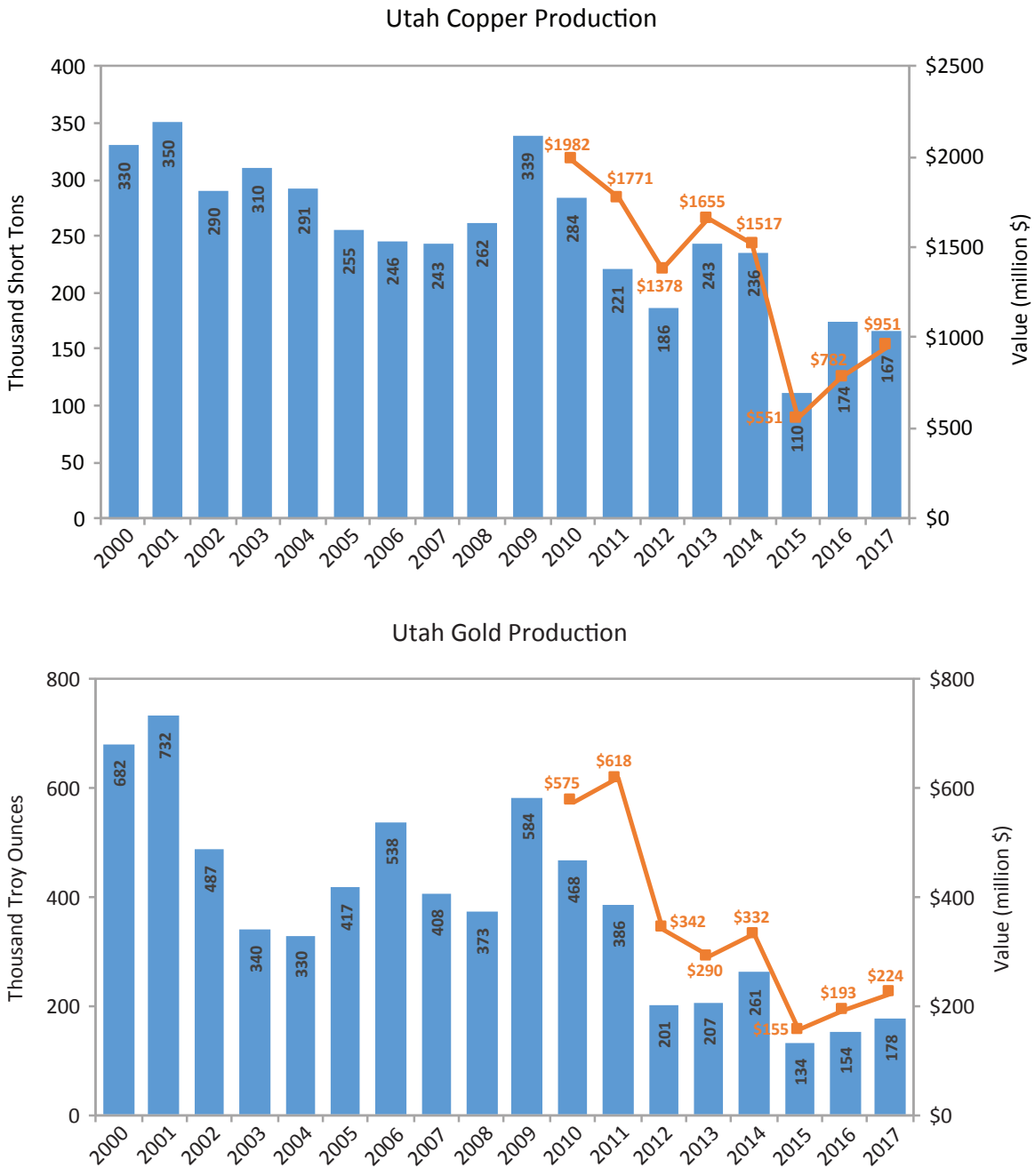


Figure 6. *Production (since 2000) and value (since 2010) of select metals. Values in nominal dollars.*

Valley mining district of San Juan County (figure 7). The ore is primarily hosted in the Cretaceous Dakota Sandstone. The company began mine development in 2005 and plant construction was completed in 2006. Following some startup difficulties, Lisbon Valley Mining has been operating successfully since 2009. Total mine production from 2005 to 2017, inclusive, is estimated at 140 million pounds of copper. Annual copper cathode production is down for the second consecutive year. Lisbon Valley also has an ongoing exploration program, primarily on trend to the southeast.

Eurasian Minerals staked 61 lode claims on the northwest nose of the Lisbon Valley anticline in 2016, about 8 miles northwest of the Lisbon Valley copper operation. The target is sediment-hosted copper associated with splays of the mineralizing faults in the hanging wall of the large Lisbon Valley normal fault.

Rocky Range District

Tamra Mining Company purchased the assets of CS Mining from bankruptcy court in August 2017. They control a group of small, Oligocene-age (~30 Ma) copper deposits in the Rocky Range, Beaver County (figure 7). These properties include several prograde, anhydrous, low-sulfidation copper skarns. In 2009, a flotation mill was built and open pit mining began.

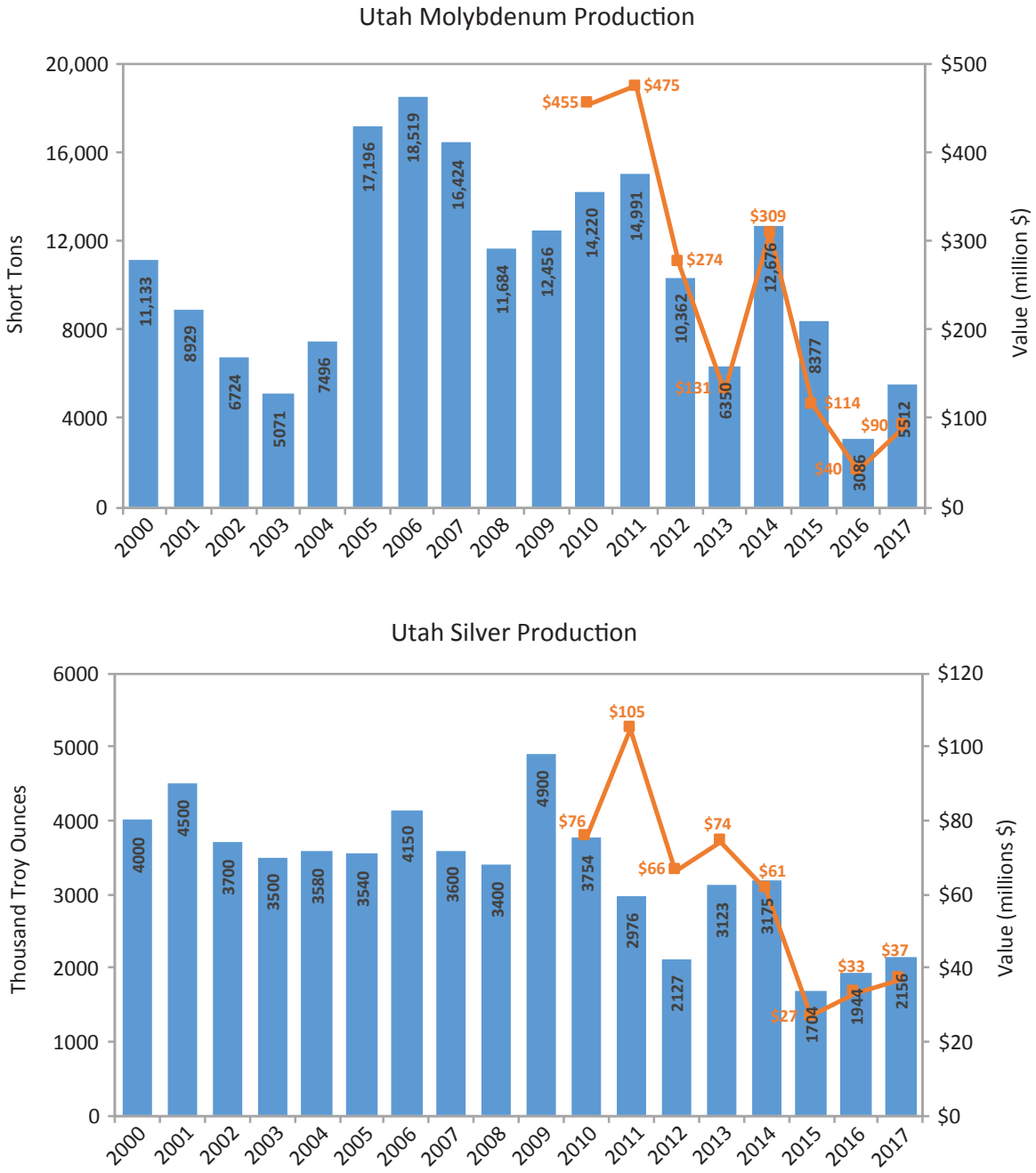


Figure 6. *Continued.*

The mill experienced poor copper recovery due to the mixed sulfide-oxide nature of the ore and operations were halted. The mine and mill were successfully restarted in 2012 but continued to suffer from low copper recovery through 2015. CS Mining began construction of an agitation leach SX-EW plant in 2015 to more effectively process their copper oxide ore and reprocess the older flotation mill tailings to recover additional metal. Mining ceased in 2016 but restarted in late 2017. The new SX-EW plant began operating using the tailings, resulting in minor copper production in 2017. CS Mining production from 2008 to 2017 (inclusive) is estimated at approximately 27 million pounds of copper. The 2017 production is down significantly from 2016, but specific numbers are unavailable.

Spor Mountain District

The Spor Mountain mining district lies on the west flank of the Thomas Range in west-central Juab County (figure 7) and is the world's premier beryllium producer, accounting for approximately 70% of the world's annual production. The beryllium occurs in epithermal, carbonate-replacement deposits in a basal Miocene-age tuffaceous sediment along northeast-trending, half-graben-bounding, normal faults. Over 3.5 million st of ore with an average grade of greater than 0.2% beryllium has been mined from 10 small- to medium-sized pits since production began in 1969. Annual production has declined the last three consecutive years. Total Spor Mountain

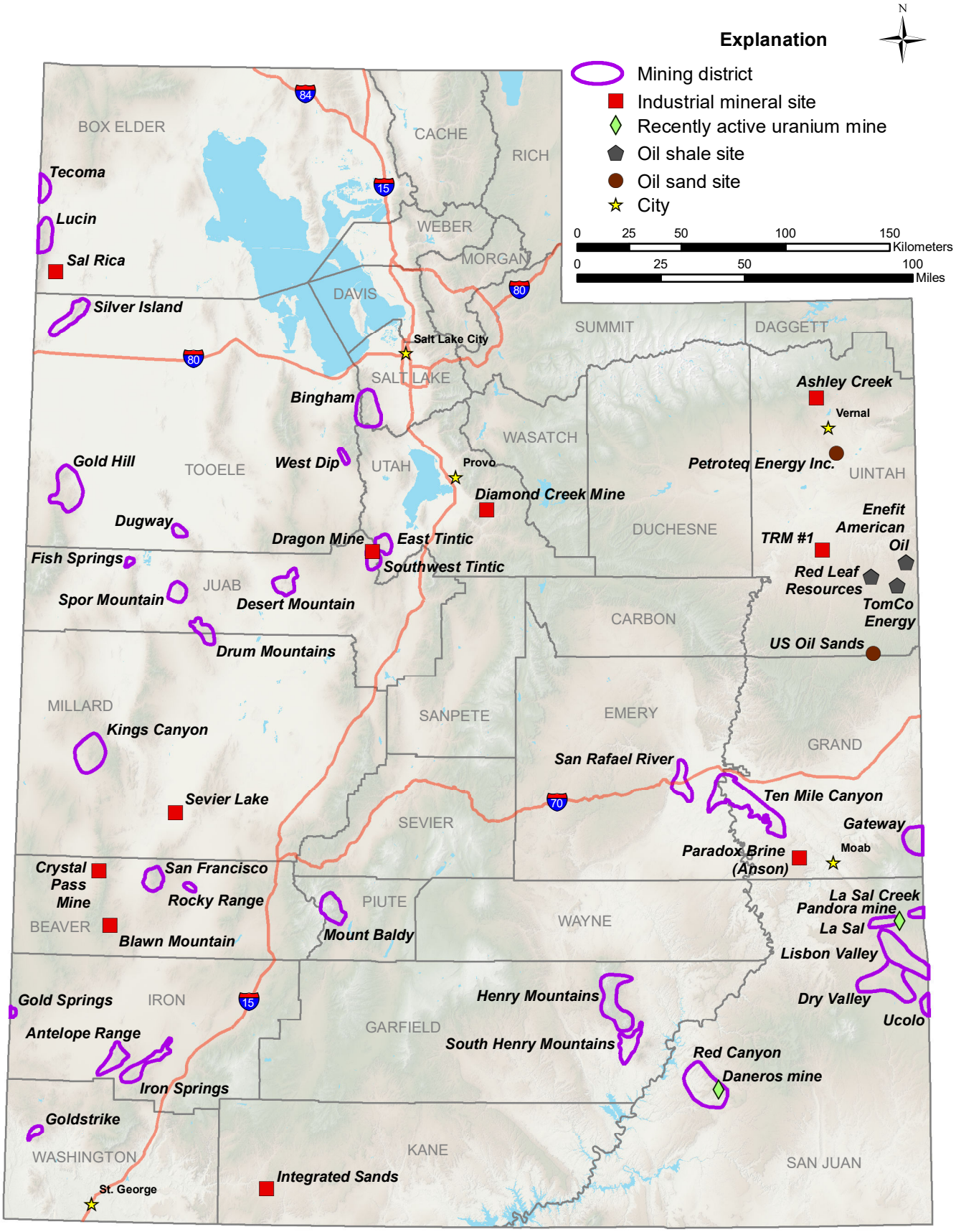


Figure 7. *Select base and precious metal, industrial mineral, uranium, oil shale, and oil sand exploration and development activity locations in Utah.*

Table 2. *Select metal exploration and development projects in Utah, 2017. Districts are shown on figure 7.*

Property	Commodity	District	County	Company	Progress
Blair Project	Silver-Gold	Antelope Range	Iron	Silver Peak Exploration - Tuvera Exploration, Inc.	Mapping and sampling completed, drilling planned
Bingham Orbit	Copper-Gold-Molybdenum	Bingham	Salt Lake - Tooele	Kennecott Utah Copper Company	Ongoing deep exploration - development drilling
Coyote Knoll	Silver-Gold	Desert Mountain	Juab	Desert Mountain	Property acquired by Desert Mountain Gold, Inc.
Golden Drum Section	Gold-Silver	Drum Mountains	Millard	Golden Dragon, LLC	300 rock samples collected, option dropped
Wildcat	Gold-Silver	Drum Mountains	Juab	Renaissance Gold, Inc.	TroyMet dropped their option
Dugway	Polymetallic	Dugway	Tooele	Eurasian Minerals, Inc.	Property staked in 2016
Burgin	Lead-Silver	East Tintic	Utah	Chief Consolidated Mining Company	Acquired by LeadFX Inc., no exploration completed
West Desert (Crypto)	Polymetallic	Fish Springs	Juab	InZinc Mining Ltd.	NI 43-101* completed, drilling planned for 2018
Gold Hill	Gold-Silver	Gold Hill	Tooele	Newmont USA Ltd.	Very large land position and drilling ongoing
Kiewit	Gold-Silver	Gold Hill	Tooele	Desert Hawk Gold Corp.	Small open pit and heap leach; on standby for 2017
Gold Springs	Gold-Silver	Gold Springs	Iron	TriMetals Mining, Inc.	New NI 43-101* completed (Lane and others, 2017)
Goldstrike	Gold-Silver	Goldstrike	Washington	Liberty Gold Corp. (Pilot Gold, Inc.)	NI 43-101* (Gustin and Smith, 2016) and 191 holes
Bromide Basin	Gold	Henry Mtns.	Garfield	Bromide Mining, LLC	Drilling program in progress
Iron Mountain	Iron	Iron Springs	Iron	CML Metals Group	Mine closed in 2014
Kings Canyon	Gold	Kings Canyon	Millard	Pine Cliff Energy Ltd.	NI 43-101* completed, no work reported in 2017
Thompson Knoll	Polymetallic	Kings Canyon	Millard	Inland Explorations Ltd. and BCM Resources	NI 43-101* completed, drilling planned
Copper Warrior	Copper	Lisbon Valley	San Juan	Eurasian Minerals, Inc.	Property staked in 2016, no work reported
Lisbon Valley Copper	Copper	Lisbon Valley	San Juan	Lisbon Valley Mining Company, LLC	Operating copper mine with ongoing exploration
East Canyon	Gold-Silver	Lucin	Box Elder	Tuvera Exploration, Inc.	NI 43-101* completed, no work reported in 2017
North Lucin	Gold-Silver	Lucin	Box Elder	Newmont USA Ltd.	Property dropped
Deer Trail	Polymetallic	Mount Baldy	Piute	Quintana WRP Holding Co.	NI 43-101* completed, no work reported in 2017
Milford Copper	Copper	Rocky Range	Beaver	Tamra Mining Company, LLC	Open pit copper mines with agitation leach SX-EW
Frisco Project	Copper-Gold; Lead-Silver	San Francisco	Beaver	Alderan Resources Ltd.	Four targets, nine holes completed totaling 9453 ft
Frisco Summit	Copper	San Francisco	Beaver	Kennecott Utah Copper Company	320 lode claims were staked in 2017
Speedway	Gold	Silver Island	Tooele	Genesis Gold Corp.	One core hole completed, property dropped
SWT Porphyry	Copper-Molybdenum	Southwest Tintic	Juab	Freeport-McMoRan Exploration Corp.	Ongoing drilling program
Spor Mountain	Beryllium	Spor Mountain	Juab	Materion Natural Res.	No new developments
TUG	Gold-Silver	Tecoma	Box Elder	Newmont Mining Corporation	Acquired from West Kirkland Mining
Goldstrike East	Gold-Silver	Unorganized	Washington	John Zimmerman	Gold in Claron Formation
West Mercur	Gold	West Dip	Tooele	Ash-ley Woods, LLC	Acquired 6300 acres of State land and unpatented claims

* An NI 43-101 is a formal Canadian National Instrument technical report prepared to a codified set of rules for public reporting of mineral exploration and development data on properties operated by companies listed on Canadian stock exchanges.

district production is estimated at over 15.9 million pounds of beryllium. Materion Corporation has proven and probable reserves of about 9 million st at 0.25% beryllium, which at current production rates, would support well over 75 years of continued beryllium production (Materion, 2018).

Goldstrike District

Liberty Gold (formerly Pilot Gold) acquired a 3800-acre land package encompassing the historical mining area of the Goldstrike Miocene-age sediment-hosted gold-silver mining district in Washington County in 2014 (figure 7). The lacustrine conglomerate, sandstone, and limestone of the basal Paleocene-Eocene Claron Formation are the primary host. Production from Goldstrike in the late 1980s and early 1990s totaled approximately 210,000 oz of gold and 198,000 oz of silver from 12 small open pits along a 3.5-mile-long northeast trend (Gustin and Smith, 2016).

Liberty Gold assimilated and digitized the massive historical mine database, including over 1500 drill holes and 100,000 blast holes. They used this data to produce a three-dimensional model of the geology and mineralization. They drilled 18 holes in 2015, 174 holes in 2016, and 285 in 2017 for a grand total of 245,100 feet, an average of 514 feet per hole (Liberty Gold, 2018). Drilling highlights from the 2017 program include:

- 3.14 ppm gold over 105 feet from surface,
- 1.93 ppm gold over 50 feet,
- 1.61 ppm gold over 45 feet,
- 3.40 ppm gold over 35 feet,
- 2.03 ppm gold over 20 feet,
- 1.01 ppm gold over 40 feet,
- 2.09 ppm gold over 20 feet,
- 1.79 ppm gold over 35 feet, and
- 1.20 ppm gold over 165 feet.

Liberty's plans are to complete a new Canadian National Instrument (NI) 43-101 mineral resource estimate in the first quarter of 2018 to be followed up by a preliminary economic assessment (PEA).

Gold Springs District

The Gold Springs mining district is located along the Nevada border in Iron County (figure 7). The district contains Miocene-age, low-sulfidation, epithermal, gold-silver quartz-adularia-calcite vein/stockwork deposits. TriMetals Mining acquired a 6000-acre block of ground in the district in 2014. In 2017, a new NI 43-101 was released on the Gold Springs property. This report shows a measured and indicated resource on the Jumbo gold-silver stockwork of 29,800,000 st at 0.55 ppm gold and 10 ppm silver using a pit-constrained 0.25 ppm gold cutoff for a total gold resource of 479,000 ounces. The PEA calls for a 15,000 ton per day, open pit, heap leach operation with a 2:1 stripping ratio (Lane and others, 2017).

In 2016, TriMetals drilled an additional 25 reverse circulation holes totaling 13,970 feet (average 559 feet per hole). This drilling includes encouraging results such as:

- 70 feet at 1.09 ppm gold and 6.5 ppm silver,
- 170 feet at 0.97 ppm gold and 10.0 ppm silver,
- 90 feet at 1.19 ppm gold and 17.3 ppm silver,
- 40 feet at 1.53 ppm gold and 10.4 ppm silver, and
- > 0 feet at 1.53 ppm gold and 2.5 ppm silver.

San Francisco District

Alderan Resources acquired a very large block of land in mid-2016 covering most of the San Francisco district, Beaver County (figure 7). This property consists of two large blocks of patented claims totaling an estimated 4000 acres and a block of 253 unpatented claims. Alderan spent considerable time assimilating the historical mining and exploration data, mapped and sampled the district, flew a very detailed aeromagnetic survey, and completed a property-wide induced polarization survey. They used this data to define four primary targets: Cactus copper breccia pipe, Cactus Canyon porphyry copper, Accrington (Imperial) copper-zinc skarn, and Horn (Horn Silver) zinc-lead-silver replacement deposit. Historical production from the Cactus breccia pipe is roughly 1.4 million tons at 1.23% copper, 0.33 ppm gold, and 7 ppm silver. Alderan began their drilling program in 2017 on the Cactus copper breccia pipe and adjoining targets. They completed nine core holes totaling about 9450 feet in 2017 and drilling continued into 2018.

Kennecott Exploration Company staked about 320 unpatented lode mining claims (roughly 6600 acres) east of the large Alderan property in the San Francisco mining district. These claims are in the general area of the extensive Frisco Summit sulfide system, a possible deep porphyry copper target.

West Dip District

Ashley Woods has assembled a 10,600-acre land position at its West Mercur project in the West Dip district, Tooele County (figure 7). The project is located 3 miles west of the historic Mercur gold mine, which produced nearly 3.5 million ounces of gold between 1890 and 1997 (Mako, 1999). The Carlin-type gold deposits at West Mercur occur in west-dipping Mississippian-age Great Blue Limestone, the same host formation as that at Mercur, but on the opposite limb of the Ophir anticline. The project area includes several historical prospects and small mines that were worked for gold between 1895 and 1917. Previous Getty drilling on the property included an intersection of 300 feet of 0.3 ppm gold including 60 feet at 0.75 ppm gold.

Southwest Tintic District

In 2007, Quaterra Resources acquired about 3200 acres of patented and unpatented mining claims encompassing the Southwest Tintic porphyry copper system in Juab County (figure 7). The property includes a known historical resource of about 400 million st averaging 0.33% copper and 0.01% molybdenum (Krahulec and Briggs, 2006; Krahulec, 2015). In a 2009 joint venture with Quaterra, Freeport-McMoRan Exploration Corporation began an integrated program of geological mapping, geochemical sampling, and geophysical surveying, including seven exploration holes that were drilled in 2010 and 2011. Freeport-McMoRan acquired the property from Quaterra outright in 2015 and drilled three additional holes in 2017.

Kings Canyon District

Inland Explorations' Thompson Knolls property lies on the west slope of the Confusion Range, Kings Canyon mining district, in west-central Millard County (figure 7). The Thompson Knolls targets include porphyry/skarn associated with a covered magnetic high and sediment-hosted gold-silver. In 2015, a 51% interest in the Thompson Knolls project was optioned to BCM Resources. BCM assimilated the previously generated exploration data, staked 25 new unpatented lode claims, completed two additional geophysical surveys, and produced a NI 43-101 technical report on the property (Redfern, 2016). The most notable previous result at Thomson Knolls is a 1996 exploration hole drilled by Centurion Mining (CKC-96-10), which intersected 30 feet of 8.31 ppm gold and 26.9 ppm silver from 250 to 280 feet (Redfern, 2016). Two deep holes are planned for 2018.

Vanadium

Utah currently produces no vanadium, but the upswing in the demand for vanadium redox batteries (VRB) has increased vanadium prices and interest in vanadium exploration and development. There are two major sources of vanadium: stratiform ultramafic iron-titanium-vanadium deposits and sandstone uranium-vanadium deposits; although not currently important sources, phosphorites, black shales, and some oil field brines are also enriched in vanadium. Historically, vanadium has always been a byproduct in other mining operations. The ultramafic iron-titanium-vanadium deposits are primarily located in Precambrian shields typified by the Bushveld Complex of South Africa.

The escalating vanadium price has renewed interest in the exploration and development of vanadium-rich uranium-vanadium mines to feed the existing White Mesa dual circuit uranium-vanadium mill. In Utah, the highest vanadium grades are associated with Upper Jurassic Morrison-hosted uranium-vanadium deposits. Historically, the largest vanadium-producing districts in Utah are the La Sal, Dry Valley, Ucolo, and La Sal Creek districts of San Juan County (figure 7). All of these districts had average grades of over 1% V_2O_5. Anfield Energy is also studying the possibility of adding a vanadium circuit to their idled 1000-ton-per-day, acid-leach-type, Shootaring uranium mill to take advantage of the rapidly escalating vanadium price.

INDUSTRIAL MINERALS

Production and Values

Industrial mineral production in Utah during 2017 had an estimated value of $1.2 billion (figure 3), which was an increase of 5% from 2016. The largest value contributor was the brine- and evaporite-derived products that include potash, salt, and magnesium chloride. These products had a combined value of $410 million, a 14% increase in value from 2016, and account for 34% of Utah's total industrial mineral production value in 2017. The second-largest contributor was the sand and gravel, crushed stone (including limestone and dolomite), and dimension stone commodity groups. These products had a combined value of $332 million in 2017, a 9% decrease from 2016, and account for 27% of the industrial mineral total. The third-largest contribution to the value of industrial minerals production came from the Portland cement and lime product group. These products had a combined value of $248 million in 2017, a 10% increase from 2016, and account for 21% of total industrial mineral value. Together, these three commodity groups contributed 82% of the total 2017 value of industrial minerals produced in Utah. The remaining value came from, in decreasing order, phosphate, gilsonite, clay, expanded shale, and gypsum.

Potash, Salt, and Magnesium Chloride

The brine- and evaporite-derived commodities produced from Great Salt Lake include, in descending order of production, salt (NaCl), magnesium chloride, and potash (in the form of potassium sulfate or SOP). Potash, in the form of potassium chloride (muriate of potash or MOP), magnesium chloride, and salt were also produced at operations near Moab and Wendover. Some additional salt production came from an underground mine near Redmond.

Potash production in Utah totaled 444,000 st in 2017 and contributed the most value to this commodity group (figure 8). The 2017 value of produced potash was approximately $210 million, an increase of 12% from 2016 (figure 8). The higher value was due to an increase in the production and price of potassium chloride, as well as a slight increase in production of potassium sulfate. Compass Minerals Ogden produces potassium sulfate from Great Salt Lake brine, Intrepid Potash-Wendover produces potassium chloride from shallow brines in the Great Salt Lake desert, and Intrepid Potash-Moab produces potassium chloride from a solution mining operation

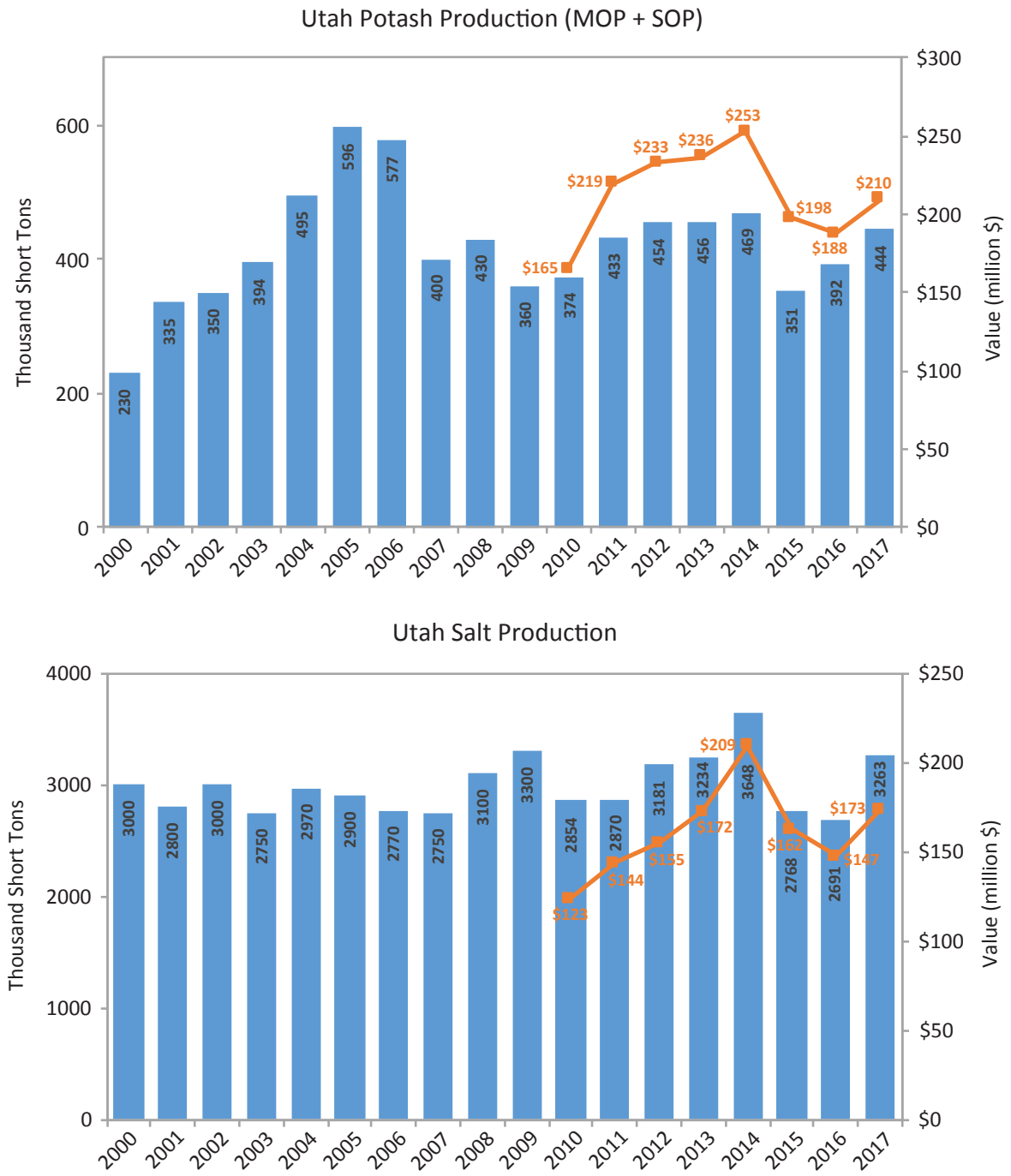


Figure 8. *Production (since 2000) and value (since 2010) of potash (in the form of potassium chloride or MOP and potassium sulfate or SOP) and salt. Values in nominal dollars.*

targeting the Pennsylvanian Paradox Formation (figure 2). Potassium sulfate has a significantly higher market value than potassium chloride. The primary use of both types of potash is for fertilizer.

Utah salt production in 2017 amounted to approximately 3.3 million st and had a production value estimated at $173 million (figure 8). About 79% of the salt was produced from Great Salt Lake brine by three operators: Compass Minerals Ogden, Cargill Salt, and Morton International, in descending production order (figure 2). The remaining 21% came from Redmond Minerals, Intrepid Potash-Wendover, and Intrepid Potash-Moab. Redmond Minerals operates an underground mine near Redmond in Sanpete County and produces salt from the Jurassic Arapien Shale (figure 2). Salt produced in Utah is used for a variety of purposes including road deicing, water treatment, and agricultural and industrial applications.

In 2017, magnesium chloride production in Utah increased to 836,000 st and had an estimated production value of about $27 million. The magnesium chloride brine was pro-

duced by Intrepid Potash-Wendover and Compass Minerals Ogden; the latter also produces small amounts of magnesium chloride flake. Magnesium chloride is commonly used as a premium road deicer and as a dust suppressant for unpaved roads.

The most significant source of brine-derived products in Utah is Great Salt Lake. An estimated 3.0 million st of total solids was produced from Great Salt Lake in 2017, including salt, potash, magnesium chloride, and magnesium metal; this production is up from the 2016 estimate of 2.5 million st. This estimate does not account for all byproducts, such as chlorine gas and hydrochloric acid, so the actual solids production is likely higher. The value of mineral and brine production from Great Salt Lake in 2017 was estimated at $545 million, which was a decrease of about 11% from 2016.

Sand and Gravel, Crushed Stone, and Dimension Stone

Sand and gravel, crushed stone, and dimension stone are produced by many private, county, state, and federal entities. Given the numerous producers of this commodity group, it was impractical for the UGS to send annual production surveys to all of the operations. However, the UGS does compile data from selected operators to track these commodities and uses USGS data for production and value estimates. During 2017, approximately 34 million st of sand and gravel was produced in Utah, down about 16% from 2016 (figure 9), and was worth $253 million (USGS, 2018c). About 11 million st of crushed stone, an 8% increase from 2016, was worth $78 million (USGS, 2018c), and several thousand tons of dimension stone was produced. Prices for crushed stone and sand and gravel increased slightly from 2016 to 2017.

Portland Cement, Lime, and Limestone

Together Ash Grove Cement and LafargeHolcim produced about 1.7 million st of Portland cement in Utah during 2017, having an estimated value of $170 million. Ash Grove Cement operates the Leamington quarry and plant east of Leamington in Juab County, while LafargeHolcim operates the Devils Slide quarry and plant east of Morgan in Morgan County (figure 2). In 2017, Portland cement production value increased 6% in 2017 due to slight increases in production and price (USGS, 2018b). Besides mining limestone for Portand cement production, the Ash Grove and Holcim mines also produce small amounts of sandstone, clay, and shale, which are minor feedstock for their cement plants.

During 2017, Graymont Western U.S. was the sole producer of lime in Utah. Lime production increased approximately 18% in 2017. Graymont Western U.S. produces high-calcium quicklime and dolomitic quicklime from their quarry and plant in the Cricket Mountains about 35 miles southwest of Delta in Millard County (figure 2). Lime is used for flue gas desulfurization, steel production, and a variety of other construction, chemical, and industrial applications.

During 2017, about 4 million st of limestone was produced for uses other than crushed stone. Most of that production was used to manufacture the aforementioned cement and lime,

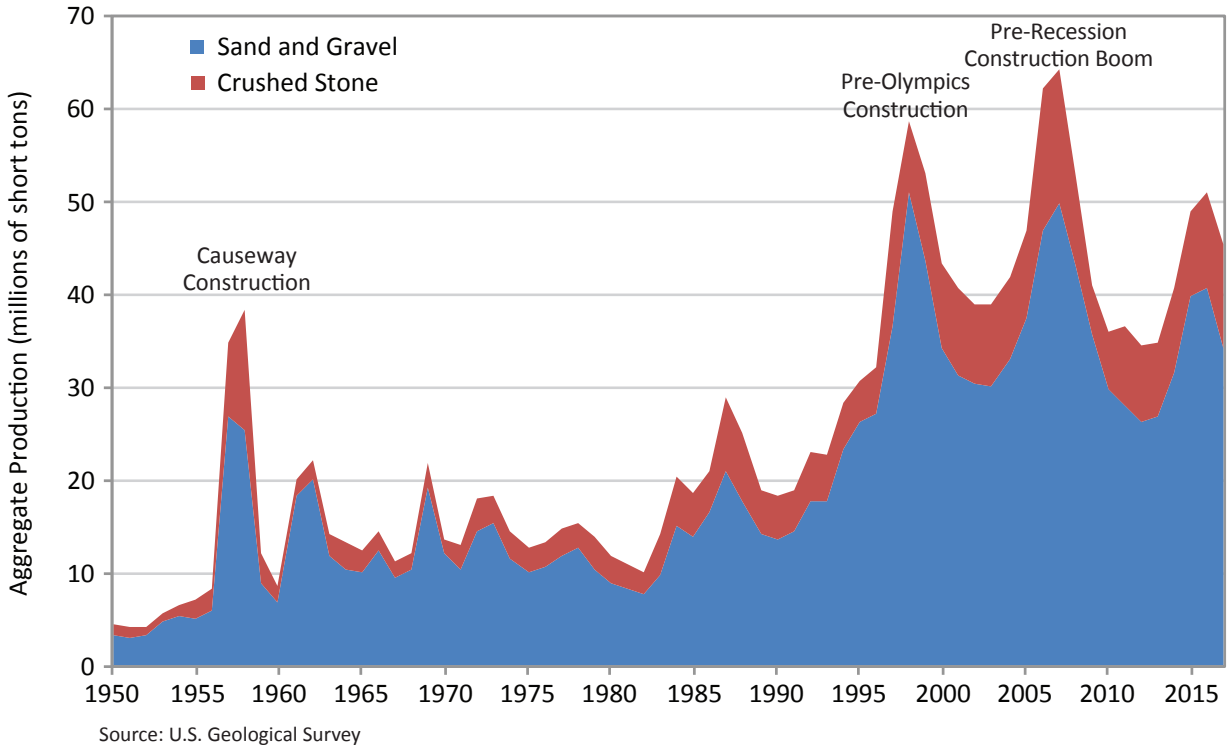


Figure 9. *Utah aggregate production, 1950–2017.*

but a few smaller operations, such as Diamond Mountain Resources in Uintah County, produce limestone for flue-gas desulfurization at coal-fired power plants. Small amounts of limestone are also used as a safety product for the coal industry. Limestone "rock dust" is used to coat the walls of coal mines to keep coal dust from accumulating.

Phosphate

Simplot Phosphates continues to be the only active phosphate producer in Utah, mining the Meade Peak Member of the Permian Phosphoria Formation. The phosphate operation is located 12 miles north of Vernal in Uintah County (figure 2). In 2017, the mine produced approximately 4 million st of ore, which was 11% more than 2016 production. The ore yielded about 1.5 million st of phosphate concentrate (P_2O_5) after processing. The concentrate is transported in slurry through a 96-mile underground pipeline to the Simplot fertilizer plant near Rock Springs, Wyoming. More than 95% of the phosphate rock mined in the United States is used to manufacture phosphoric acids to make ammonium phosphate fertilizers and animal feed supplements (USGS, 2018b).

Gilsonite

Gilsonite is a shiny, black, solid hydrocarbon that occurs in a swarm of narrow, but laterally and vertically extensive veins in the Uinta Basin. It has been mined since the late 1880s, mostly in Utah, but there has also been some minor production from the Colorado portion of the Uinta Basin. In 2017, American Gilsonite Company was the only significant producer, mining and processing gilsonite at their operation in southeastern Uintah County (figure 2). Over the past decade, gilsonite production from the Uinta Basin has ranged between 20,000 and 85,000 st per year, depending on market conditions (specific production and price data are proprietary). Production for American Gilsonite was significantly reduced in 2016 as the company underwent Chapter 11 bankruptcy reorganization. Production increased in 2017 and the company emerged from bankruptcy in early 2018. Utah is the only place in the world that contains large deposits of gilsonite, which has been shipped worldwide for use in numerous and diverse products including asphalt paving mixes, coatings, inks, and paints (Boden and Tripp, 2012). More recently, the oil and gas industry has used gilsonite as an additive in drilling fluids. Gilsonite helps control fluid loss and seepage, helps increase wellbore stability, helps prevent loss circulation, and helps stabilize shale formations.

Bentonite, Common Clay, and High-Alumina Clay

Production of bentonite and common clay totaled about 207,800 st in 2017, an 11% decrease from 2016 production. These commodities were produced at various small and large mines, often on an intermittent basis. Consequently, production and value estimates are subject to significant change on a year-to-year basis. Bentonite was produced by Western Clay and Redmond Minerals. Uses for bentonite include well drilling and foundry operations, various civil engineering applications, and as litter-box filler. The largest producer of common clay was Interstate Brick, while Ash Grove Cement and LafargeHolcim produced most of the high-alumina clay. Common clay is largely used to make bricks, whereas high-alumina clay is used to make Portland cement.

Expanded Shale

Expanded shale in Utah is produced by Utelite at their quarry and plant near Wanship in Summit County (figure 2). In 2017, Utelite produced approximately 157,500 st of expanded shale, which is a lightweight aggregate sometimes called "bloated shale" mainly used by the construction industry. Expanded shale is produced by rapidly heating high-purity shale, derived from the Cretaceous-age Frontier Formation, to about 2000°F causing it to expand and vitrify. The resulting aggregate is durable, inert, uniform in size, and lightweight, having a density about one-half that of conventional aggregates. The material is used in roof tile, concrete block, structural concrete, and horticulture additives, as well as for highway construction and geotechnical fill. About half of Utelite's production is used locally along the Wasatch Front and the rest is shipped out of state.

Gypsum

Four operators reported combined gypsum production in Utah of about 302,000 st in 2017, a 4% increase from 2016 production. The estimated value of 2017 gypsum production is $4.3 million, 18% higher than 2016. Higher value calcined gypsum production was up moderately in 2017, while lower value crude gypsum production was slightly down. The four Utah gypsum producers were Sunroc Corp., United States Gypsum Co., Diamond K Gypsum, and Nephi Gypsum (in descending production order). Two gypsum wallboard plants are located near Sigurd in Sevier County, but only the United States Gypsum plant is active (figure 2). Utah gypsum is primarily used in raw or crude form by regional cement companies as an additive to retard the setting time of cement and by the agriculture industry as a soil conditioner. Lesser amounts of the higher value calcined gypsum are used to make wallboard.

Exploration and Development Activity

Exploration and development activities involving industrial mineral commodities in Utah included potash, lithium, phosphate, hydraulic fracturing sand (frac sand), gilsonite, and calcium carbonate (table 3). This summary generally does not include development of smaller aggregate or construction material operations, which are difficult to track. The information for this section is derived primarily from company websites, press releases, DOGM records, and personal communications.

Table 3. *Select industrial mineral exploration and development projects in Utah, 2017.*

Property	Commodity; Deposit	Location	County	Company	Progress
Ashley Creek	Phosphate; Meade Peak Mbr. of Phosphoria Fm.	Uinta Basin, Ashley Creek	Uintah	Utah Phosphate Company (Nutrien)	No reported activity in 2017
Blawn Mountain	Potash; alunite alteration	Blawn Mountain; Wah Wah Mtns.	Beaver	Potash Ridge Corporation	Minimal reported activity in 2017; released updated preliminary feasibility study
Crescent Junction	Potash; Paradox Fm. evaporites	Paradox Basin	Grand	Pinnacle Potash International	No reported activity in 2017
Crystal Pass Mine	Calcium-carbonate/ Limestone; Marbleized Cambrian limestone	Wah Wah Pass	Beaver	Crystal Pass Industries LLC	Received small mine permit to produce high-calcium limestone as a feed additive for a hog farm near Milford
Diamond Creek mine	Phosphate; Meade Peak Mbr. of Phosphoria Fm.	Diamond Fork	Utah	Falcon Isle Resources	Defined a small resource of about 74,000 tons of phosphate rock; intends to mine a few thousand tons per year as organically certified phosphate
Dragon Mine	Halloysite specialty clay and iron oxide	Tintic Mtns.	Juab	Applied Minerals Inc.	Continues to investigate market possibilities for halloysite and iron oxide
Paradox Brine	Lithium; brine	Paradox Basin	Grand	Anson Resources Ltd	Re-entered two oil and gas wells to collect brine samples in early 2018
Red Valley	Lithium; brine	Black Rock Desert, west of Fillmore	Millard	Red Mountain Mining, Ltd.	Commenced a three-hole exploration program in 2017, but did not drill third hole due to disappointing results from first two holes
Sal Rica	Lithium; shallow brine	Pilot Valley	Box Elder	Westwater Resources (formerly Uranium Resources, Inc.)	Completed some limited brine sampling in shallow auger holes during 2017
TRM #1	Gilsonite; vein	Uinta Basin	Uintah	Table Rock Minerals LLC	Opened a new gilsonite mine on a SITLA lease in the Uinta Basin; reportedly began operating in 2018
Sevier Lake	Potash; shallow brine	Sevier (Dry) Lake	Millard	Crystal Peak Minerals Inc.	Published feasibility study in early 2018; Cotinued work on EIS with BLM and other cooperating agencies

Potash

For the past decade or so, interest in Utah potash has led to several potash exploration projects, but recent low potash prices have resulted in limited project advancement, with a few exceptions. During 2017, Crystal Peak Minerals made progress on a feasibility report, which was published in early 2018 (Brebner and others, 2018). They are developing an SOP project in a shallow brine deposit on the Sevier Lake playa in Millard County (figure 7). The company intends to use solar ponds and a processing plant to produce about 370,000 tons of SOP per year with an estimated mine life of 30 years. Crystal Peak Minerals has also been working with the BLM to prepare an EIS; the administrative draft is projected to be complete during the second half of 2018. Potash Ridge and Pinnacle Potash International, two companies that have completed substantial exploration programs in recent years, reported minimal activity during 2017, but Potash Ridge did release an updated prefeasibility study of their Blawn Mountain project (figure 7) (Kerr and others, 2017).

Lithium

Following increased demand and rising prices for battery materials, Utah has become a target for lithium exploration in the past few years. During 2016, thousands of lithium claims were staked in Utah, and additional activity and claim staking occurred in 2017. Several projects are focusing on lithium brines in a variety of locations including the Paradox Basin, Pilot Valley, Tule Valley, and the Black Rock Desert. Activity beyond land acquisition has been somewhat limited, but a few companies completed sampling and subsequent analyses. Westwater Resources reported lithium concentrations ranging from 10 to 100 ppm from shallow brine samples at their Sal Rica project in Pilot Valley (figure 7). The samples were collected from 14 auger holes less than 10 feet deep. Red Mountain Mining completed a two-hole drilling program in the Black Rock Desert, west of Fillmore, during the first half of 2017 to test lithium content in subsurface brine. The initial drilling program planned for three holes, but disappointing results from the first two holes led Red Mountain Mining to cancel the final hole and seemingly abandon the project. Anson Resources holds land in the Paradox Basin (figure 7) and re-entered two oil and gas wells during the first half of 2018 to evaluate lithium content in deep subsurface brines; the highest measured concentration of lithium in the sampled brine was 142 ppm.

Phosphate

During 2017, a relatively small phosphate project advanced towards production. Falcon Isle Resources has plans to produce modest amounts of organically certified phosphate from their Diamond Creek phosphate mine near Diamond Fork, Utah County (figure 7). They intend to extract a few thousand tons of phosphate rock per year from a roughly 7-foot-thick zone of the Meade Peak Member of the Permian Phosphoria Formation that grades approximately 25% to 30% P_2O_5. The company has currently outlined a resource of about 74,000 tons in a 3.3 acre area. The area was previously mined in 1980 but has since been idle. Utah Phosphate Company (a subsidiary of Nutrien [formerly Agrium]) has been evaluating a larger phosphate project near Ashley Creek, which is west of Simplot's phosphate operation, but reported no activity in 2017 (figure 7).

Frac Sand

As horizontal oil and gas wells reach ever greater lengths—laterals in the Uinta Basin now reach up to 11,000 feet—oil and gas companies have increased the amount of frac sand used in hydraulic fracturing stimulations, up to 22 million pounds per well. As a result, demand for frac sand has increased and specifications for frac sand have shifted or relaxed to some degree. Changing specifications have opened more opportunity for producing frac sand from sources in Utah. Frac sand is typically mined from unconsolidated sand deposits and friable sandstone, and, ideally, the sand grains from these deposits are well rounded, strong, and appropriately sized. A few groups have investigated potential resources in southwestern Utah, western Utah, the Uinta Basin, and elsewhere. One company, Integrated Sands, has a land position of 12,000 acres of SITLA and federal lands in Kane County, where it is hoping to develop a frac sand mine (figure 7).

Other Industrial Mineral Activity

A couple of other noteworthy small industrial mineral mines are also being developed. A new gilsonite mine (TRM #1) was permitted on a SITLA lease in the Uinta Basin south of Ouray in Uintah County (figure 7). Table Rock Minerals reportedly began operating in 2018 and has the capacity to extract about 10,000 tons of gilsonite per year. The underground mine will extract gilsonite from the Cottonwood vein. In late 2017, DOGM awarded Crystal Pass Industries a small mine permit to extract limestone at Wah Wah Pass in Beaver County (figure 7). The company intends to produce up to 20,000 tons per year of high-calcium limestone/marble as a feed additive for a hog farm near Milford. The high-calcium material will be sourced from marbleized Cambrian carbonates.

URANIUM

Historically, Utah is the third largest uranium-producing state, and the vast majority of this production came from sandstone-hosted uranium deposits of the Colorado Plateau. Utah also has two of the three licensed conventional uranium mills in the United States—Energy Fuels' White Mesa mill near Blanding and Anfield Energy's Shootaring mill near Ticaboo. Currently, only the 2000-ton-per-day, dual-circuit, White Mesa uranium-vanadium mill is operating. This mill

runs intermittently using moderate-grade uranium ore from Energy Fuels' breccia pipe deposits in Arizona and alternate feed material from out of state.

The spot price of U_3O_8 has been especially volatile over the past decade with a huge price spike up to $136/lb in June 2007 and lows of less than $45/lb in 2009–10. The spot price rebounded to $73/lb in early 2011 but fell back below $50/lb after the March 2011 Fukushima nuclear power plant disaster in Japan. Uranium spot prices continued to fall until they bottomed out at $18/lb in December 2016. The 2017 average U_3O_8 price was about $22/lb U_3O_8. Unlike the volatile spot price, long-term contract U_3O_8 prices have declined fairly gradually to about $30/lb at the end of 2017. Uranium exploration and development in Utah has varied directly with the U_3O_8 spot price fluctuations; as a result of the current low prices, there has been very little recent activity in Utah's uranium sector (figure 10).

The recent low uranium prices resulted in a halt to all of Utah's uranium mining operations in late 2012. All Energy Fuels' Utah mines were closed because they could purchase U_3O_8 on the spot market for less than their production cost. This business strategy has the added corporate benefit of preserving their existing ore reserves for times of higher prices. Energy Fuels' Daneros and Pandora-Snowball mines remain on standby (figure 7). Utah's uranium mines will likely remain idle until U_3O_8 prices exceed $50/lb, and no Utah uranium production is anticipated in 2018.

In the past few years of low spot prices, the uranium industry in Utah was consolidated by Energy Fuels and Anfield Energy as they acquired most of the promising uranium mines and prospects. Utah uranium districts and notable properties are listed in table 4 and Energy Fuels' uranium and vanadium mineral resources are shown in table 5. Anfield Energy completed a preliminary economic assessment in 2016 on their Velvet-Wood underground uranium project using a U_3O_8 price of $65/lb (Beahm and McNulty, 2016).

COAL

Production and Demand

Five Utah coal operators produced 14.4 million st of coal valued at $493 million (figure 11) from seven underground mines and one surface mine in 2017 (figure 12) (table 6). After dipping to a 30-year low in 2016, production rebounded by 3.1% in 2017 mainly due to increases at the Sufco mine. In addition, the Emery mine resumed production in late 2017, after being bought by Bronco Energy at the end of 2015. After several years of decline, employment at active or recently active mines increased slightly in 2017 to 1192 employees, but is still far below the 2028 employees recorded in 2008. Employment is expected to increase 9% to about 1300 employees in 2018 as several mines expand their operations. Demand at Utah coal-fired power plants decreased by over 2.0 million tons in 2016 and has remained at this lower level in 2017. In addition, fuel switching or closure at other U.S. coal-fired power plants outside of Utah has reduced domestic demand for Utah coal to near historical lows. However, recently Utah operators have taken ad-

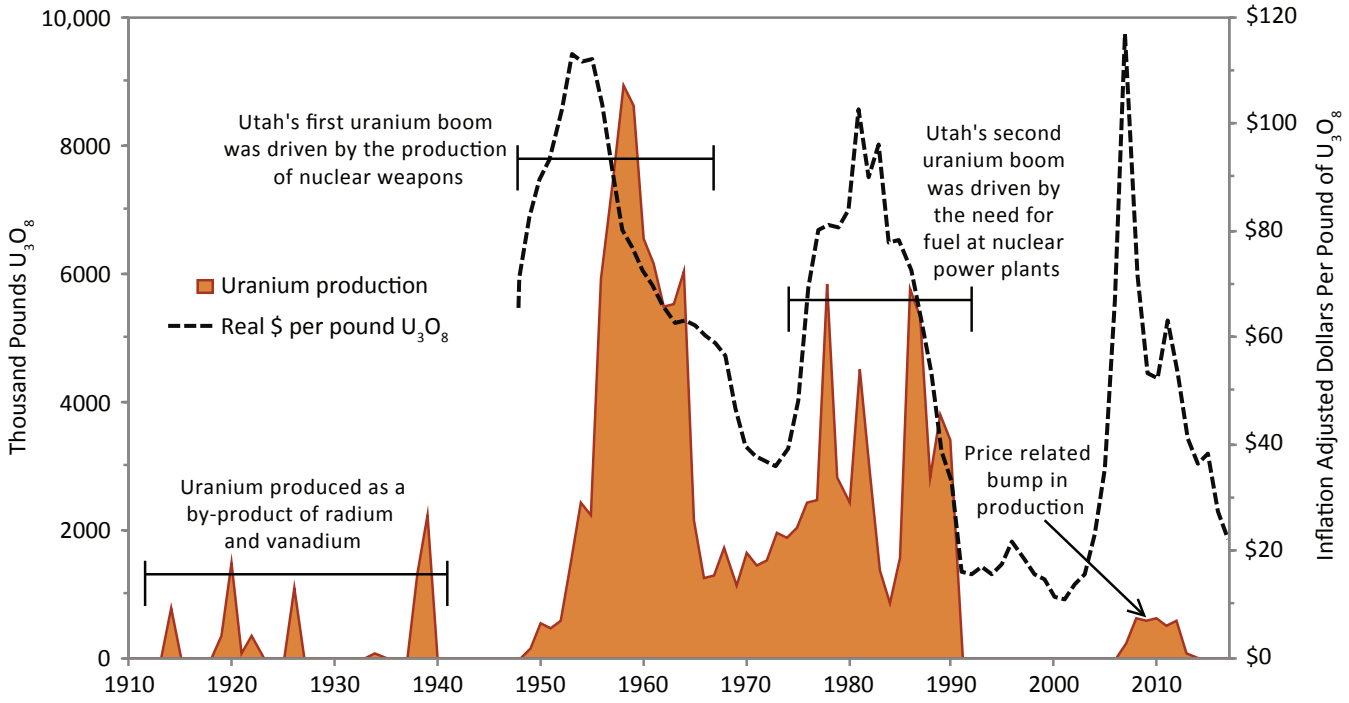


Figure 10. *Uranium production and prices in Utah, 1910–2015.*

Table 4. *Select uranium exploration and development projects in Utah, 2017. District locations are shown on figure 7.*

Property	District	County	Company	Progress
Dunn Mine	Dry Valley	San Juan	Western Uranium Corporation	Resource: 143,400 tons @ 0.12% U_3O_8
Noah	Dry Valley	San Juan	Mesa Exploration	Acquired 1280 acres of State land in 2017
Whirlwind	Gateway	Grand	Energy Fuels, Inc.	Permitted resource: 1,095,000 lb U_3O_8; on standby
Beaver-La Sal	La Sal	San Juan	Energy Fuels, Inc.	Permitted resource: 833,000 lb U_3O_8 reserve; on standby
Energy Queen	La Sal	San Juan	Energy Fuels, Inc.	Permitted resource: 1.2 M lb U_3O_8; on standby
Pandora	La Sal	San Juan	Energy Fuels, Inc.	Permitted resource: 720,000 lb U_3O_8; on standby
Redd Block	La Sal	San Juan	Energy Fuels, Inc.	Permitted resource: 1.3M lb U_3O_8
La Sal #2	Lisbon Valley	San Juan	Laramide Resources Ltd.	Resource: 808,000 tons at 0.167% U_3O_8
Velvet-Wood	Lisbon Valley	San Juan	Anfield Resources Inc.	PEA* NI 43-101** completed (Beahm and McNulty, 2016)
Daneros	Red Canyon	San Juan	Energy Fuels, Inc.	Permitted 142,000 lb U_3O_8 inferred resource; on standby
Deep Gold	San Rafael River	Emery	Western Uranium Corporation	Indicated resource: 308,800 tons @ 0.272% U_3O_8
San Rafael	San Rafael River	Emery	Baobab Asset Management LLC.	Indicated resource: 758,050 tons at 0.23% U_3O_8
Copper Bench	South Henry Mountains	Garfield	Energy Fuels, Inc.	Indicated resource: 2.93M lb U_3O_8
Frank M	South Henry Mountains	Garfield	Anfield Resources Inc.	Resource: 1.1 M tons at 0.1% U_3O_8
Indian Bench	South Henry Mountains	Garfield	Energy Fuels, Inc.	Indicated resource: 1.74M lb U_3O_8
Southwest	South Henry Mountains	Garfield	Energy Fuels, Inc.	Indicated resource: 3.3M lb U_3O_8
Tony M	South Henry Mountains	Garfield	Energy Fuels, Inc.	Permitted resource: 4.83M lb U_3O_8
Highlands	Ten Mile Canyon	Grand	Highlands Natural Resources Plc.	Property dropped
Sage Plain	Ucolo	San Juan	Western Uranium Corporation	Permitted resource: 798,000 lb U_3O_8

* A PEA is a preliminary economic assessment.

** An NI 43-101 is a formal Canadian National Instrument technical report prepared to a codified set of rules for public reporting of mineral exploration and development data on properties operated by companies listed on Canadian stock exchanges.

vantage of a strengthening export market, sending 3.1 million tons of coal overseas to Asia in 2017, the highest since 1997. With the export market continuing to expand, Utah coal production is expected to increase to about 14.8 million tons in 2018.

In 2017, the vast majority of Utah coal, 11.3 million st, was produced from the Wasatch Plateau coalfield; 2.3 million st come from mines in the Book Cliffs coalfield, 0.7 million st from the Alton coalfield, and now 0.1 million st from the Emery coalfield (figure 13; table 6). The majority of Utah coal in 2017, 90% (12.9 million st), was produced from federal land, while only 2.0% (0.3 million st) was from state-owned land (figure 14). Federal coal production has dominated in Utah since July 2011, when the Deer Creek mine's state-owned Mill Fork coal tract reverted back to federal ownership after a 22.3 million st coal production threshold was reached. This reversion dramatically increased the amount of coal produced on federal land, from 48% in 2011 to 84% in 2012. The remainder of Utah's 2017 coal production came from private lands (7.9%, 1.1 million st) at the Castle Valley, Emery, and Coal Hollow mines, and county lands at the Skyline mine (0.4%, 0.1 million st).

The total amount of Utah coal distributed to the U.S. market in 2017 was 11.9 million st (figure 15). As recently as 2002, 23.3 million st of Utah coal was distributed; nearly 13.2 million st was exported to other states, and 10.1 million st was used in state. In 2017, only 2.2 million st of Utah coal was shipped to other states, while 9.7 million st was used locally. The vast majority of Utah coal, about 81% (9.6 million st), went to the electric utility market mainly within the state (figure 16). Utah coal deliveries to the industrial sector remained steady at 2.3 million st in 2017, but this is significantly less than peak deliveries of 4.4 million st in 2003. Total annual domestic deliveries of Utah coal in 2018 are expected to remain in the 11 to 12 million st range, reflecting low overall domestic demand.

Table 5. *Energy Fuels' uranium and vanadium mineral resources*.*

Mine	District	Resource Classification	Tons	eU_3O_8 %	V_2O_5 %	Pounds eU_3O_8	Pounds V_2O_5
Whirlwind	Gateway	Indicated	188,000	0.29	0.96	1,095,000	3,598,000
Whirlwind	Gateway	Inferred	437,000	0.23	0.74	2,000,000	6,472,000
Beaver/La Sal	La Sal	Measured	215,000	0.19	0.98	800,000	4,199,000
Beaver/La Sal	La Sal	Indicated	9000	0.18	0.96	33,000	173,000
Beaver/La Sal	La Sal	Inferred	29,000	0.11	0.60	67,000	352,000
Energy Queen	La Sal	Measured	262,000	0.19	0.97	971,000	5,100,000
Energy Queen	La Sal	Indicated	81,000	0.17	0.87	268,000	1,409,000
Energy Queen	La Sal	Inferred	43,000	0.09	0.48	79,000	417,000
Pandora	La Sal	Measured	196,000	0.18	0.94	701,000	3,682,000
Pandora	La Sal	Indicated	7000	0.14	0.73	19,000	99,000
Pandora	La Sal	Inferred	18,000	0.12	0.66	44,000	232,000
Redd Block	La Sal	Measured	336,000	0.19	0.98	1,260,000	6,615,000
Redd Block	La Sal	Indicated	35,000	0.07	0.35	47,000	249,000
Redd Block	La Sal	Inferred	95,000	0.09	0.47	171,000	900,000
Daneros	Red Canyon	Indicated	20,000	0.36	--	142,000	--
Daneros	Red Canyon	Inferred	7000	0.37	--	52,000	--
Copper Bench	South Henry Mountains	Indicated	500,000	0.29	--	2,930,000	--
Copper Bench	South Henry Mountains	Inferred	500,000	0.32	--	3,240,000	--
Indian Bench	South Henry Mountains	Indicated	220,000	0.40	--	1,740,000	--
Indian Bench	South Henry Mountains	Inferred	250,000	0.42	--	2,090,000	--
Southwest	South Henry Mountains	Indicated	660,000	0.25	--	3,300,000	--
Southwest	South Henry Mountains	Inferred	210,000	0.14	--	580,000	--
Tony M	South Henry Mountains	Indicated	1,030,000	0.24	--	4,830,000	--
Tony M	South Henry Mountains	Inferred	650,000	0.17	--	2,170,000	--
Sage Plain	Ucolo	Measured	240,000	0.16	1.32	772,000	6,350,000
Sage Plain	Ucolo	Indicated	13,000	0.10	0.77	26,000	199,000
Sage Plain	Ucolo	Inferred	10,000	0.13	0.94	25,000	188,000

* Energy Fuels, 2018, Energy Fuels Inc. United States Security and Exchange Commision Form 10-K for the year 2017: Online, https://www.energyfuels.com/wp-content/uploads/2018/03/EFR-2017.12.31-10K-FINAL-filed-3.9.2018-2.pdf, accessed April 2018.

The demand for Utah coal has sharply decreased over the past few years as coal-fired power plants have closed or switched to natural-gas-fired generation. Gas overtook coal as the leading fuel for U.S. power plants in 2016, while coal used to produce electricity fell to the lowest level since 1982 (EIA, 2018). Within Utah, the Carbon coal-fired power plant outside the town of Helper closed in April 2015 because it was cost prohibitive to retrofit the old plant with new EPA-mandated emission-reducing technology. This removed about 600,000 st of coal from the Utah market. After 2016, consumption of coal dropped 16%, a reduction of 2.0 million st, at Utah's coal-fired power plants (excluding the Bonanza plant in the Uinta Basin which is supplied with Colorado coal). Most of this reduction occurred at the Intermountain Power Plant (IPP) near the town of Delta (1.2 million st) as the City of Los Angeles, the majority owner, has begun to purchase less electricity from the plant as it favors renewable sources or natural gas-fired generation. In fact, Los Angeles has stated it will no longer purchase any coal-fired electricity from IPP after its power purchase agreement expires in 2025. In addition, as new solar-generated electricity (mostly from California and Nevada, but also from Utah) floods the grid during the day, Utah's Hunter and Huntington coal-fired power plants have been forced to throttle back their operations during these peak solar times, thus consuming less coal. In California and Nevada, both significant past markets for Utah coal, several coal-fired generation plants have closed or converted to natural gas to comply with stricter air-quality standards. In Nevada for example, the Reid Gardner coal-fired power plant shut down units 1 through 3 in 2014 and shutdown unit 4 in 2017; Utah used to supply up to 1.5 million st of coal to Reid Gardner. In California, several co-generation plants that formerly used Utah coal have shut down or converted to natural gas in recent years. On the industrial side, Utah's historically largest consumer of coal, Kennecott Utah Copper, is in the process of converting their power plants from

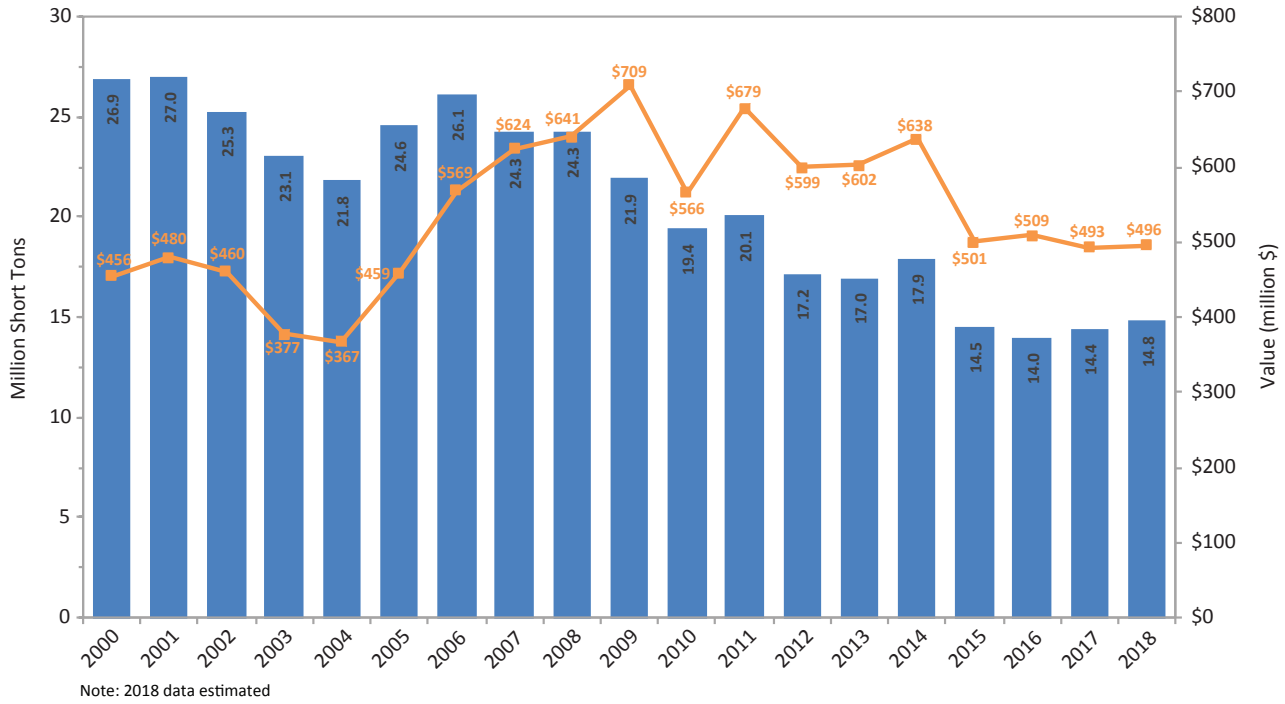


Figure 11. *Utah annual coal production and value in nominal dollars, 2000–2018.*

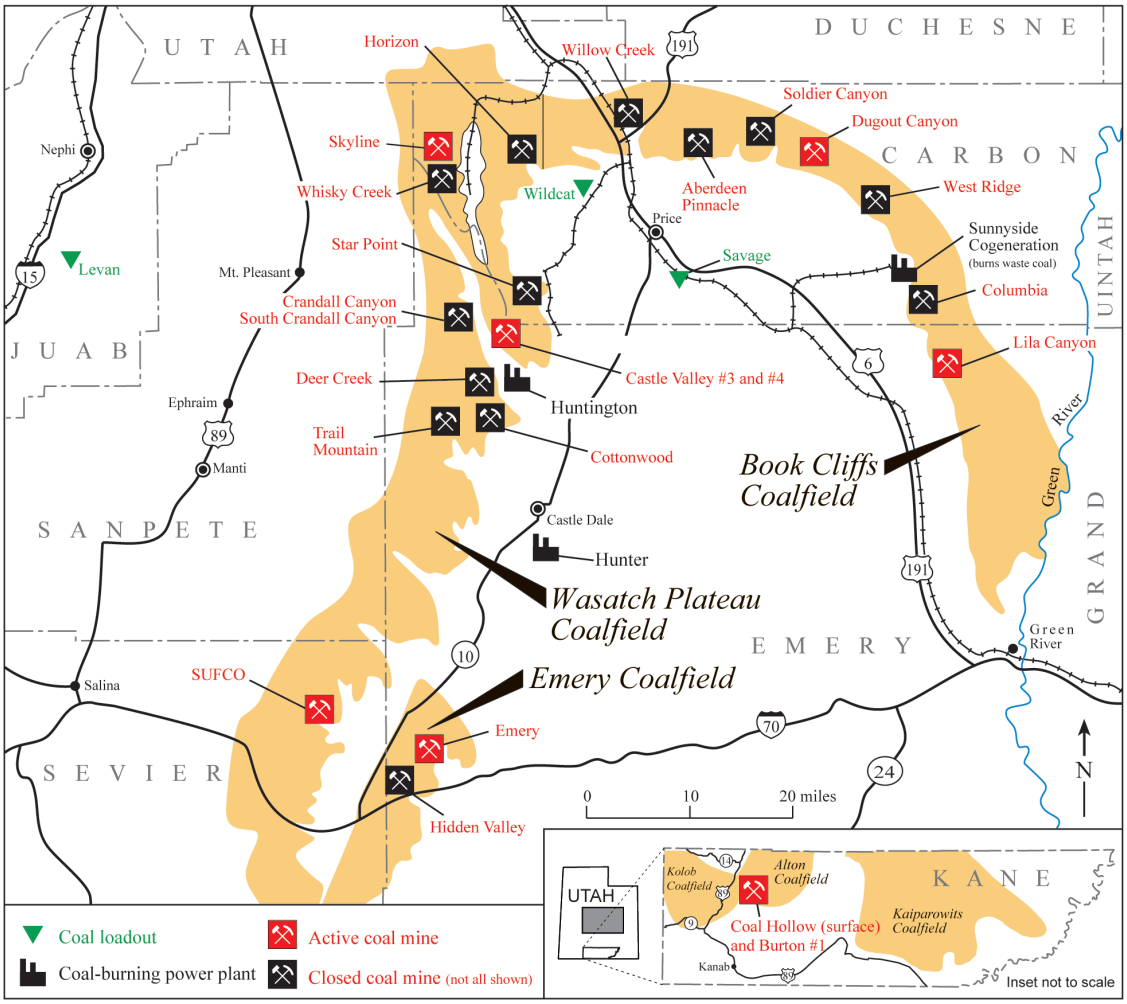


Figure 12. *Location and status (at time of publication) of Utah coal mines and associated facilities.*

Table 6. *Coal production in Utah by coal mine, 2009–2018.*

Company	Mine	County	Coalfield	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*
				thousand short tons									
Canyon Fuel Company, LLC - Bowie Resources Partners, LLC[1]	Dugout Canyon	Carbon	Book Cliffs	3291	2307	2395	1588	561	676	763	650	626	600
	Skyline #3	Carbon/Sanpete/Emery[2]	Wasatch Plateau	2910	3050	2950	1954	3135	4170	4409	4767	4389	4000
	SUFCO	Sevier	Wasatch Plateau	6748	6398	6498	5651	5959	6539	6095	5375	5947	5300
Bronco Utah Operations, LLC[3]	Emery	Emery	Emery	1238	999	--	--	4	--	--	--	135	500
Castle Valley Mining, LLC - Rhino Resource Partners, LP[4]	Castle Valley #3	Emery	Wasatch Plateau	--	--	--	--	--	--	218	170	205	250
	Castle Valley #4	Emery	Wasatch Plateau	651	--	592	1004	875	1061	757	724	754	750
East Mountain Energy - PacifiCorp	Deer Creek	Emery	Wasatch Plateau	3833	2954	3143	3295	2785	2083	15	--	--	--
Hidden Splendor Resources, Inc. - America West Resources, Inc.	Horizon	Carbon	Wasatch Plateau	194	270	370	210	--	--	--	--	--	--
West Ridge Resources, Inc. - UtahAmerican Energy, Inc. - Murray Energy Corp.	West Ridge	Carbon	Book Cliffs	3063	3355	3566	2579	2629	2514	1580	--	--	--
UtahAmerican Energy, Inc. - Murray Energy Corp.	Lila Canyon	Emery	Book Cliffs	--	72	157	304	257	335	350	1587	1638	2800
Alton Coal Development, LLC	Coal Hollow	Kane	Alton	--	--	403	570	747	555	316	671	724	600
	Burton #1	Kane	Alton	--	--	--	--	--	--	11	34	--	--
Total				21,928	19,405	20,074	17,155	16,953	17,933	14,513	13,978	14,417	14,800

Source: UGS coal company questionnaires

*Forecast

[1]Owned by Arch Coal until summer 2013

[2]2017 production by county: Sanpete = 43,949 tons; Emery = 136,203 tons; Carbon = 4,208,538 tons; 2009–2016: all production in Carbon

[3]Owned by CONSOL Energy until 2015

[4]Owned by C.W. Mining (Co-op) until summer 2010, mines formerly called Bear Canyon

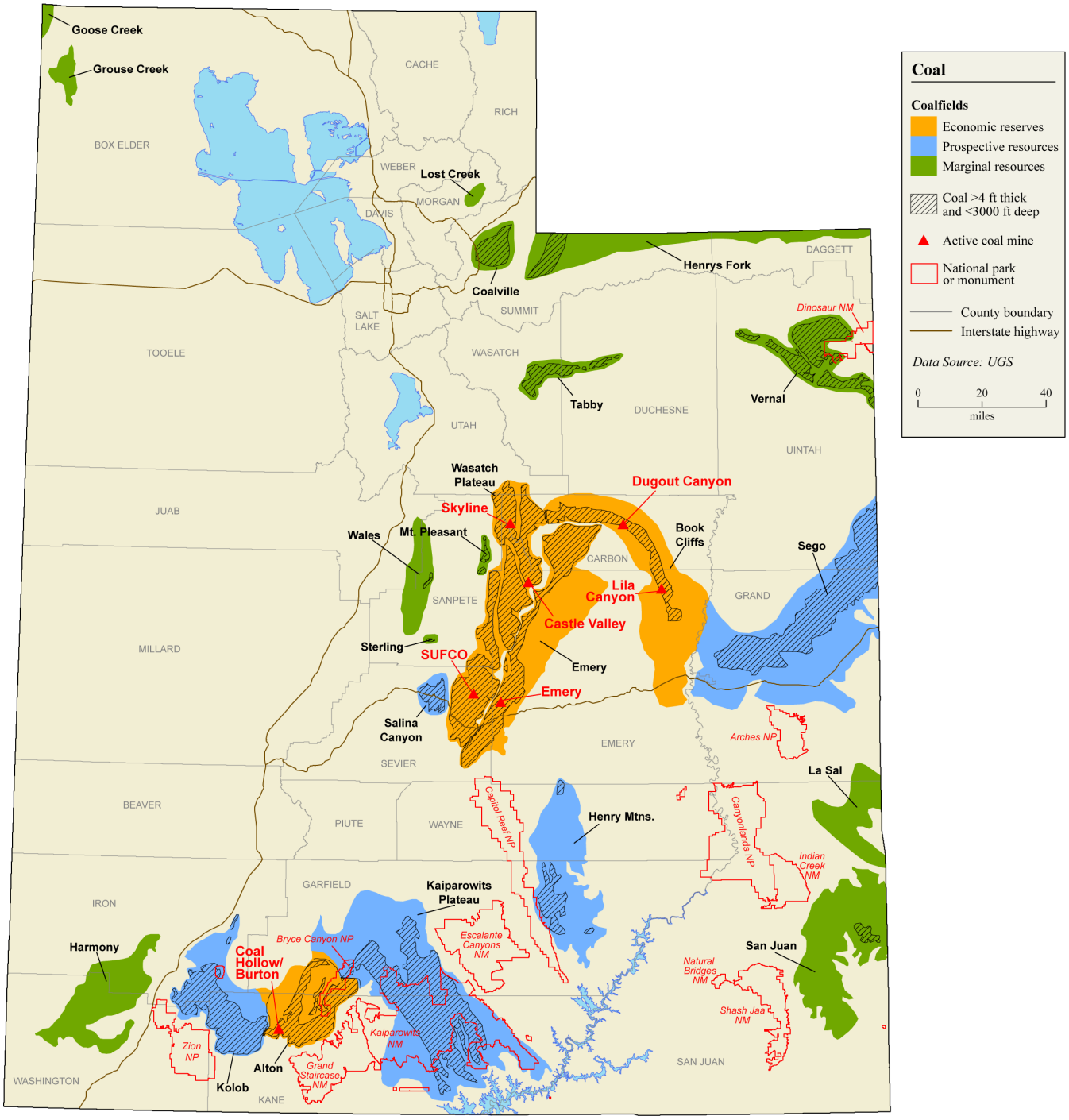


Figure 13. *Location of active Utah mines and coal fields.*

coal to natural gas. In the late 2000s, Kennecott burned nearly 500,000 st of Utah coal; in 2017 this amount has been reduced to only about 100,000 tons.

Foreign exports of Utah coal averaged about 2.9 million st per year in the 1990s, peaking at 5.3 million st in 1996 (figure 15). Beginning in the early 2000s, foreign exports dropped dramatically, with no exports reported in 2007. Starting in 2008, Utah coal exports revived, reaching 2.9 million st in 2014, before dropping again in 2015 to only about 0.7 million st and 1.0 million st in 2016. However, an expanding foreign export market has provided new opportunity for Utah coal operators. With diminished port capacity on the west coast of the U.S., Utah operators have turned to alternate port facilities (e.g., Guayamas, Mexico) to send their coal overseas. It is estimated that Utah operators could export as much as 3.5 million st in 2018.

For detailed statistics on Utah's coal industry (including information previously published in the annual Utah Coal Report), refer to extensive data tables located on the UGS's Utah Energy and Mineral Statistics website: https://geology.utah.gov/resources/energy/utah-energy-and-mineral-statistics/.

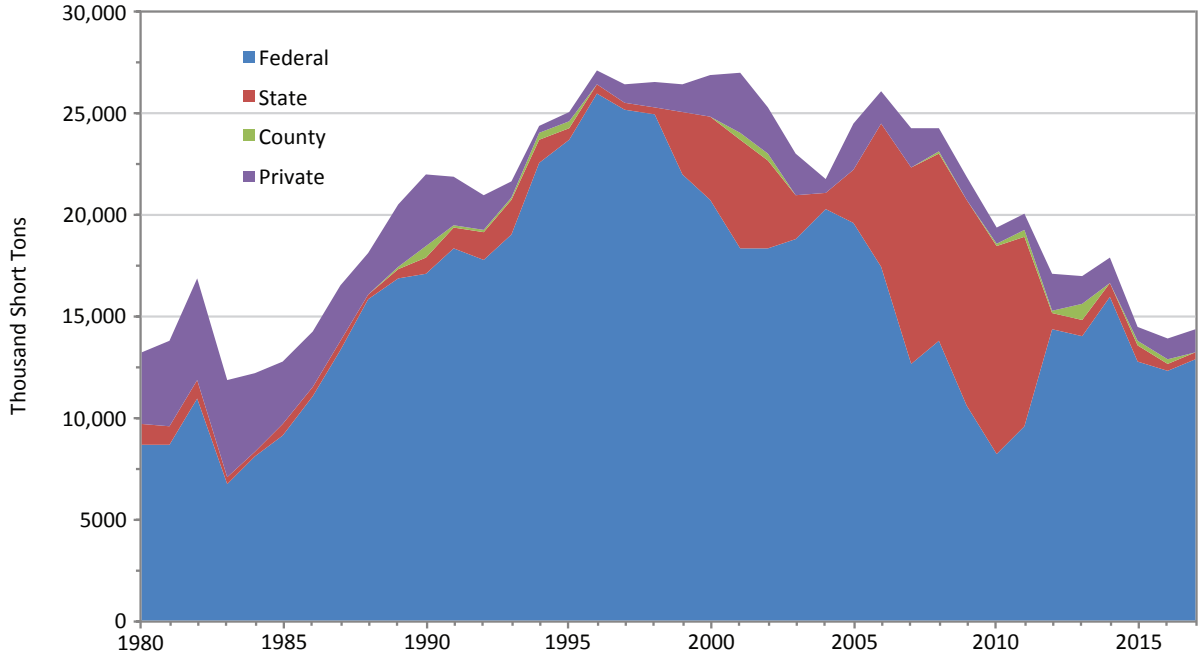


Figure 14. *Coal production in Utah by land ownership, 1980–2017.*

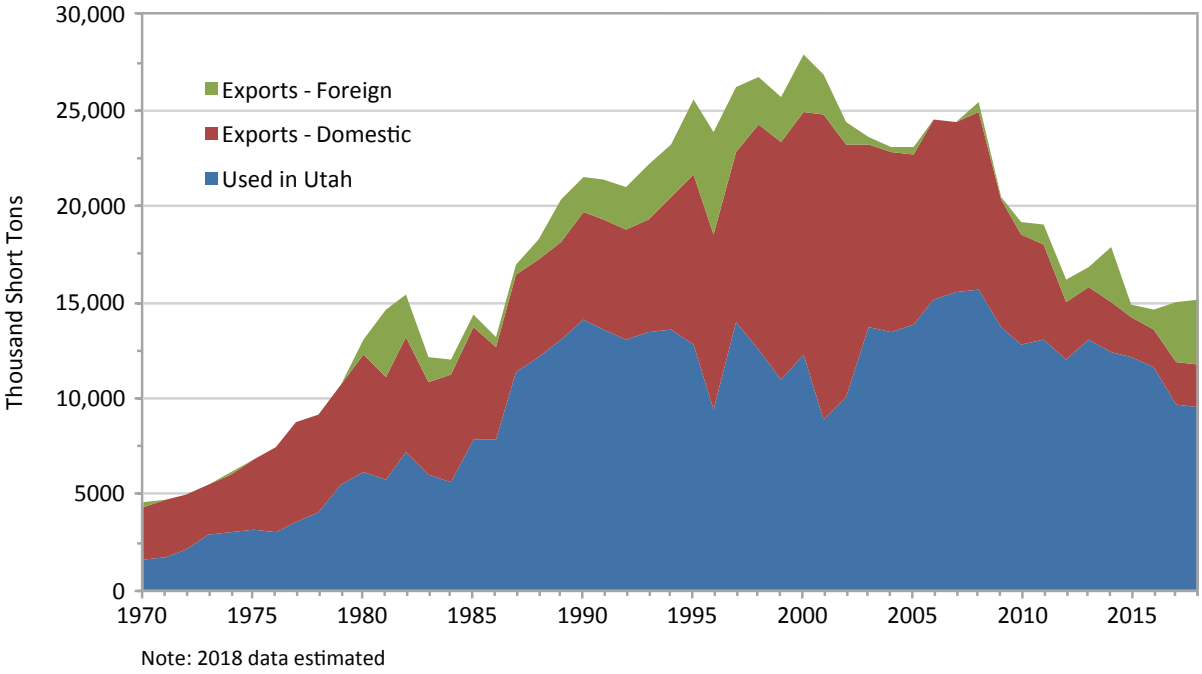


Figure 15. *Distribution of Utah coal, 1970–2018.*

Exploration and Development Activity

UtahAmerican Energy, Inc. – Murray Energy Corp.

Lila Canyon mine: The Lila Canyon mine is located south of Horse Canyon in the Book Cliffs coalfield in Emery County. In spring of 2010, the company finished construction on 1200-foot-long rock slopes and began development work in the Sunnyside coal bed, producing 72,000 st of coal in 2010. Mine development work continued from 2011 through 2015, and total coal production averaged about 300,000 st per year during this time. Coal production increased substantially in 2016, up to 1.6 million st, after the now-closed West Ridge mine's refurbished longwall mining equipment was installed, and production remained at the 1.6 million st level in 2017. Coal production is expected to increase to about 2.8 million tons in 2018 due to an expanding foreign export market. Coal is presently mined from federal leases where the merged upper and lower Sunnyside bed is up to 13 feet thick.

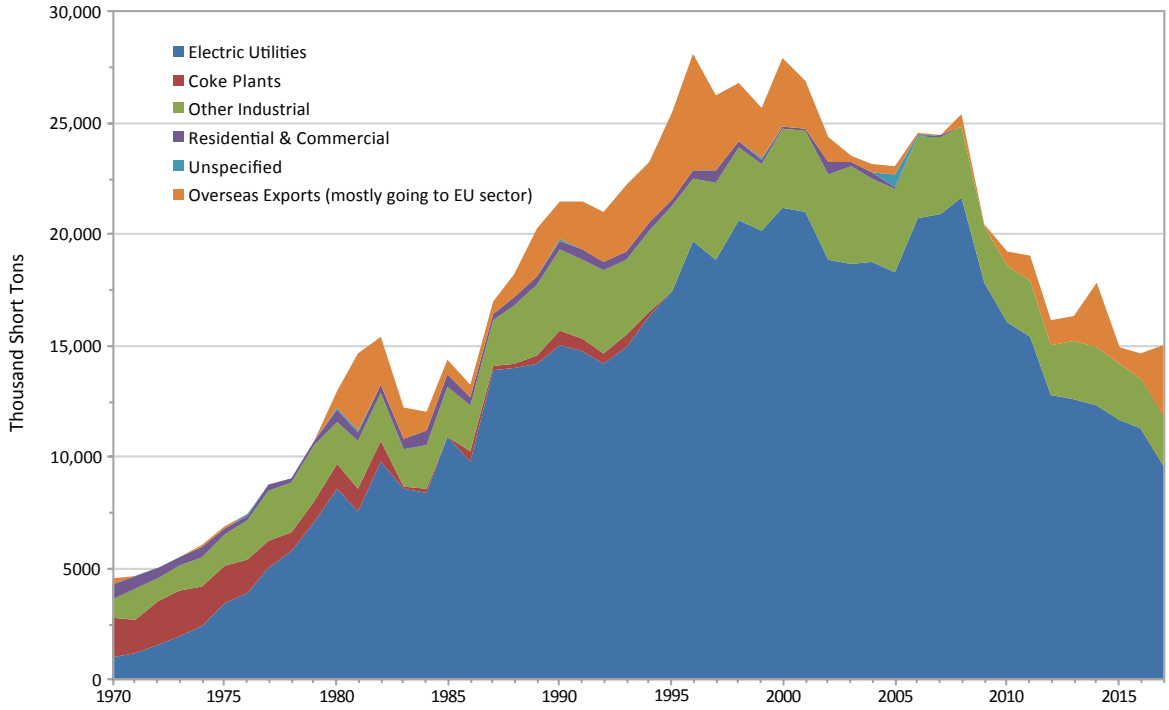


Figure 16. *Distribution of Utah coal by end use, 1970–2017.*

West Ridge Resources, Inc. – West Ridge mine: The West Ridge mine began operation in 1999 in the Book Cliffs coalfield with production from the lower Sunnyside bed. Production at West Ridge averaged 2.6 million st between 2012 and 2014, but production in 2015 decreased to about 1.6 million st as UtahAmerican depleted the remaining recoverable coal under lease and shut down operations in late November 2015. Total production from the mine's 17 years of operation was about 43.7 million st.

Canyon Fuel Company – Bowie Resource Partners, LLC

Bowie Resource Partners bought Canyon Fuel Company (the Dugout, Sufco, and Skyline mines) from Arch Coal in summer 2013. Bowie, based in Louisville, Kentucky, owns the mines in a joint venture with Galena Private Equity Resources Fund, a unit of the Amsterdam-based commodity trader Trafigura Beheer BV. Trafigura sells the venture's coal production. In late 2017, it was announced that Canyon Fuel would be sold to Canyon Consolidated Resources, a partnership formed largely by Murray Energy with several other minor investors; however, the sale fell through less than a month after the announcement.

Dugout Canyon mine: In 2012, Dugout operators completed mining the longwall panels in its current mine plan and switched to running a room-and-pillar operation because of the reduction in coal demand. This switch in mining method resulted in a large reduction in coal production, from a high of 4.6 million st in 2005 to only 561,000 st in 2013. Current production is from the Rock Canyon bed and has averaged about 675,000 st between 2014 and 2017, using two continuous miners, and is expected to remain at this level. Mining will remain in the Rock Canyon until at least 2020 when operations will shift to back to the previously mined Gilson seam.

Skyline mine: Canyon Fuel Company's Skyline mine, located in the Wasatch Plateau coalfield, is currently moving mining operations from the Lower O'Connor "A" bed on their Winter Quarters lease in Carbon County to the recently permitted Flat Canyon federal coal tract in Sanpete County, near the border with Emery County. Continuous miners entered Flat Canyon in October 2017 and longwall production was expected to start in Spring 2018. Production in 2017 dipped slightly with the commencement of the move and totaled 4.4 million st. In fact, production took place in three separate counties: 4.2 million st in Carbon, 136,000 in Emery, and 44,000 in Sanpete. This coal production is the first in recent history in Sanpete County. Production is expected to also dip in 2018 to about 4.0 million st due to the move. The Flat Canyon tract is estimated to contain up to 50 million st of recoverable coal reserves in the Lower O'Connor A and B beds, as well as minor reserves in the Flat Canyon bed.

Sufco mine: Sufco is Utah's largest coal producer and the 13th largest producing underground coal mine in the United States (2016 data). Located in the Wasatch Plateau coalfield, Sufco is also the only active mine in Sevier County. Sufco produced over 5.9 million st of coal in 2017 from the upper Hiawatha bed, 11% more than in 2016, but 25% less than record high production of 7.9 million st achieved during 2006. Production at Sufco is expected to decrease to 5.3 million st in 2018 and production on current leases will last about another

year before operations shift to the Greens Hollow tract (continuous miners in 2019 and longwall in 2020), which contains an estimated 56 million st of recoverable coal. The Greens Hollow federal coal tract was leased to the sole bidder, Canyon Fuels Company, in January 2017 for $23 million, or $0.41 per ton of recoverable coal.

Fossil Rock Resources – Bowie Resources Partners, LLC

Cottonwood tract: On December 31, 2007, SITLA held a sale of the Cottonwood Competitive Coal Leasing Unit. The tract was awarded to Ark Land Company, a subsidiary of Arch Coal, Inc., also the former owner of Canyon Fuel Company. Two coal leases were issued, one for 8204 acres covering lands within the 1998 land exchange Cottonwood Coal Tract and the other for 600 acres within an adjacent SITLA section. In mid-2011, the Cottonwood lease was transferred to Fossil Rock Resources, a subsidiary of PacifiCorp and Rocky Mountain Power, as part of a settlement of litigation between the two companies. The Cottonwood tract is adjacent to PacifiCorp's existing, but inactive, Train Mountain federal lease. Total recoverable coal in the Hiawatha bed for the combined leases is estimated to equal 49 million st. Following the announcement of the closure of the Deer Creek mine in early 2015, Fossil Rock Resources and its coal reserves were sold to Bowie Resources.

Bronco Utah Operations, LLC

Emery mine: Bronco Utah Operations bought the Emery mine from CONSOL Energy in December 2015. The Emery mine produced about 1 million st annually from the Ferron Sandstone I bed from 2005 through 2010, then CONSOL idled the mine due to low coal demand. Bronco developed new portals into the I bed in early 2017, producing 135,000 st of coal while readying the mine for full production. At full capacity, the Emery mine could produce from 1.0 to 1.5 million st per year using up to three continuous miner sections. The thick I seam, up to 12 feet, contains significant reserves to the south and could support mining for many years.

Rhino Resource Partners, LP

Castle Valley mines: Rhino purchased the Bear Canyon mines from C.W. Mining in 2010 and changed their name to Castle Valley. Between 2011 and 2014, operators produced a total of 3.5 million st from the Tank bed (#4 mine). In 2015, production restarted in the Bear bed (#3 mine). In 2017, production from the Tank totaled 754,000 st and production from the Bear equaled 205,000 tons. Total production for both mines is expected to remain near the 1.0 million st level in 2018; however, production will decrease in the nearly-depleted Tank and increase in the Bear. Further plans include reentering the Blind seam sometime in 2018.

Alton Coal Development

Coal Hollow and Burton #1 mines: In 2011, Alton Coal Development began production at a new coal mine in the Alton coalfield in southern Utah's Kane County. The Coal Hollow mine produces subbituminous Dakota Formation coal from the Smirl bed, which averages about 10,000 Btu/ lb, about 1% sulfur, and 8% ash. Surface-mining production at the company's Coal Hollow mine on private property peaked in 2013 at 747,000 st before decreasing to 316,000 st in 2015 as the reserves on the southern property were depleted. In the spring of 2014, highwall mining began in the mine's open pits in an effort to recover coal with less surface disturbance. Also, during this time, permitting was underway to begin mining the northern fee tract, which commenced production in 2016. The Coal Hollow surface mine produced 671,000 st during 2016 and 724,000 st in 2017. After experiencing difficulty producing coal using the highwall mining machine, Alton Coal commenced underground room and pillar mining in late 2015 at the Burton #1 mine. Total production from the underground mine in 2015 was only 11,000 st. Production was increased to about 34,000 st in the first half of 2016 before problems establishing an approved roof control program idled the underground mine in the second half of 2016. Alton Coal Development's application to acquire an adjacent federal coal lease, a process begun in 2004, was affected when a federal coal leasing moratorium was declared in January 2016 by the BLM. Under a new administration, the BLM lifted the coal leasing moratorium in March 2017, providing a new opportunity for Alton Coal to receive a lease on federal coal adjacent to its private leases before the private coal is exhausted (in about 2 to 3 years). As of this writing, a final Record of Decision on the nearly completed Environmental Impact Statement had not yet been announced by the BLM. If a new federal lease is acquired, the Alton Coal operation would likely continue to be a combination of surface and underground mines.

UNCONVENTIONAL FUEL

Oil Shale

The upper Green River Formation in the Uinta Basin of Utah contains one of the largest deposits of oil shale in the world. The oil shale deposit contains an estimated in-place resource of 1.3 trillion bbls (USGS Oil Shale Assessment Team, 2011) and a potential economic resource of 77 billion bbls (Vanden Berg, 2008). The richest Green River oil shale horizon is the Mahogany zone, where individual beds can yield 80 gallons of oil per ton of rock. The Mahogany zone is 70 to 120 feet thick and is accessible via extensive outcrops along the eastern and southern flanks of the basin.

Exploration and Development Activities

The outcrop accessibility, low dip, and shallow cover of Utah oil shale deposits make conventional surface/underground

mining and surface retort the preferred technology to recover oil from the shale. Currently, at least four companies are pursuing oil shale development in Utah: Enefit American Oil, Red Leaf Resources, TomCo Energy, and Dragon Shale.

Enefit American Oil is an Estonian company that has land holdings of over 27,000 acres in the Uinta Basin (figure 7), including 18,000 acres of private land, 4000 acres of state leases, and 5000 acres of federal land. On the southern, private portion of their property, Enefit seeks to develop a full-scale oil shale operation consisting of a surface and/or underground mine, surface retorts and circulating fluidized bed combustion units, and a shale oil upgrader. During 2017, the BLM extended Enefit's Research Development and Demonstration lease on 160 acres of federal land. Enefit has also been pursuing the completion of an EIS for a utility corridor that crosses BLM land which is needed to support their development plans. The EIS was approved and published to the federal register in May 2018 and is currently open for public comment.

Red Leaf Resources is a Utah company with multiple state oil shale leases in the southeastern part of the Uinta Basin (figure 7). Red Leaf has developed a modified in situ retort process called EcoShale technology. The process involves surface mining oil shale from a pit, lining the pit with an impermeable clay layer, placing the oil shale back in the pit via pipes, and covering the filled pit (capsule) with clay and topsoil. Shale in the capsule is retorted by hot air circulating through the pipes. Reclamation can commence while the capsule is still retorting the shale. This process was tested on a pilot area at the Seep Ridge lease and the company has acquired a large-mine permit to build a near-commercial-scale capsule. Red Leaf is continuing engineering studies and is currently evaluating the possible benefits of reusable capsules that may improve costs per barrel of oil. In March 2012, Red Leaf announced a joint venture with Total E&P USA Oil Shale (a U.S. affiliate of Total SA). Total intended to fund an 80% share of an experimental capsule system (known as EPS), which was estimated at approximately $200 million. However, in March 2017 Total announced its withdrawal from the Utah joint venture. A favorable settlement was reached, and Red Leaf is considering its options for both continued development of its Seep Ridge project and other opportunities to further advance its EcoShale technology.

TomCo Energy is a United Kingdom-based company with 2919 acres of SITLA leases in the Uinta Basin (figure 7) where they have a measured resource of 126 million bbls of oil. TomCo announced in March 2017 that it has set up TurboShale Inc, an oil shale technology company that will, subject to funding, seek to develop a relatively low-cost, radio-frequency-heating technology. TomCo has plans to field test the technology that TurboShale is developing on one of their leases, known as the Holliday Block, and site preparation for that test is expected to begin August 2018.

Another company investigating Utah's oil shale resources is Dragon Shale. Instead of producing liquid fuels, they are focusing on producing organic compounds from the shale for use in higher value markets such as personal care products, adhesives, or drilling fluids. Dragon Shale intends to use modular plants to process oil shale on site and has an agreement to potentially pursue this opportunity on land owned by the Colorado-Utah Oil Shale Company.

Oil Sand

North America has the largest oil sand (also known as tar sand or bituminous sand) resources in the world, the vast majority of which are in Canada. Utah oil sand, though small compared to Canadian resources, is the largest resource in the United States. Utah oil sand deposits contain 14 to 15 billion bbls of in-place oil and have an additional inferred resource of 23 to 28 billion bbls. Twenty-four individual deposits exist in the Uinta Basin, mainly around the periphery, and an additional 50 deposits are scattered throughout the central and southeastern part of the state. Utah's major oil sand deposits individually have areal extents ranging from 20 to over 250 square miles, as many as 13 pay zones, gross thickness ranging from 10 to more than 1000 feet, and overburden thickness ranging from zero to over 500 feet. Similar to oil shale, conventional mining methods would likely be used to extract oil sand.

With the relatively lower crude oil prices seen in the past few years and the relative ease of recent oil production from tight oil reservoirs, there is less incentive for advancing bitumen extraction and upgrading techniques to move Utah's oil sand toward successful and sustainable development. Challenges facing oil sand extraction in Utah have included permitting and legal challenges, process efficiency, site accessibility, adequate infrastructure, water availability, environmental concerns, and the heterogeneity of reservoir deposits. However, despite these challenges and competition from traditional drilling, multiple companies are still exploring the development of Utah's oil sand deposits.

Exploration and Development Activities

US Oil Sands holds 32,005 acres of bitumen extraction rights on SITLA leases within the PR Springs oil sand deposit in the southern Uinta Basin (figure 7). In 2011 and 2012, the company drilled and defined a discovered resource of 184 million barrels, as outlined in an NI 51-101 report. This resource is on 5930 acres of their leased land (known as the PR Springs Project area) and represents the largest oil sand holding in the United States. Their additional 26,075 acres (known as Cedar Camp and NW areas) hold future exploration opportunities. Within a portion of the PR Springs Project area, the company acquired all the necessary permits for development of a surface mine/solvent extraction project on which work commenced in the second half of 2013. Since that time, financial challenges, including a drop in crude oil prices, caused

the company to go into receivership (similar to bankruptcy) in 2017. In early 2018, a sale solicitation process for the company had begun.

Another Utah oil sand deposit that consistently generates interest is Asphalt Ridge near Vernal, Utah. Several companies have tried to develop oil sand operations in the area, but only limited commercial activity has occurred. During 2017, Petroteq Energy (formerly MCW Energy Group until mid-2017) relocated and upgraded its processing plant to their mine site at the former Temple Mountain area, which is on the southeast end of Asphalt Ridge (figure 7). The plant, which employs a solvent-based extraction process, was upgraded to a capacity of 1000 barrels of oil per day, with intentions to begin commercial production in 2018. Vivakor, another company interested in developing oil sand at Asphalt Ridge, is similarly pursuing bitumen extraction via solvents and mobile production units.

ACKNOWLEDGMENTS

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