

UTAH MINING 2022

Metals, Industrial Minerals, Uranium, Coal, and Unconventional Fuels

by Andrew Rupke, Stephanie E. Mills, Michael D. Vanden Berg, and Taylor Boden



CIRCULAR 136
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2023

UTAH MINING 2022

Metals, Industrial Minerals, Uranium, Coal, and Unconventional Fuels

by Andrew Rupke, Stephanie E. Mills, Michael D. Vanden Berg, and Taylor Boden

Cover Photo: *Holcim's Devil's Slide quarry adjacent to their cement plant. The quarry exposes the Jurassic Twin Creek Limestone which is mined for use in cement production.*

Suggested citation:

Rupke, A., Mills, S.E., Vanden Berg, M.D., and Boden, T., 2023, Utah mining 2022—metals, industrial minerals, uranium, coal, and unconventional fuels: Utah Geological Survey Circular 136, 32 p., <https://doi.org/10.34191/C-136>.



CIRCULAR 136
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2023

STATE OF UTAH
Spencer J. Cox, Governor

DEPARTMENT OF NATURAL RESOURCES
Joel Ferry, Executive Director

UTAH GEOLOGICAL SURVEY
R. William Keach II, Director

PUBLICATIONS
contact
Natural Resources Map & Bookstore
1594 W. North Temple
Salt Lake City, UT 84116
telephone: 801-537-3320
toll-free: 1-888-UTAH MAP
website: utahmapstore.com
email: geostore@utah.gov

UTAH GEOLOGICAL SURVEY
contact
1594 W. North Temple, Suite 3110
Salt Lake City, UT 84116
telephone: 801-537-3300
website: geology.utah.gov

Although this product represents the work of professional scientists, the Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding its suitability for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product.

CONTENTS

INTRODUCTION	1
2022 Utah Mining Industry Summary	1
Critical Minerals	4
BASE AND PRECIOUS METALS	7
Production	7
2022 Utah Mineral Production Value Summary	7
Utah Mining Updates for 2022	10
Exploration and Development	10
Utah Exploration in 2022	11
Utah Exploration Highlights	11
INDUSTRIAL MINERALS	16
Production	16
Sand and Gravel, Crushed Stone, and Dimension Stone	16
Potash, Salt, and Magnesium Chloride	17
Portland Cement, Pozzolan, Lime, and Limestone	18
Phosphate	18
Uintaite (Gilsonite®)	19
Clay and Shale	19
Silica and Industrial Sand	19
Gypsum	19
Lithium	20
Exploration and Development	20
Lithium	20
Fluorspar	21
Halloysite	21
Potash	21
URANIUM	22
Production	22
Exploration and Development	22
COAL	23
Production and Distribution	23
Exploration/Development Updates for 2022/2023	30
UNCONVENTIONAL FUELS	30
Oil Shale	30
Oil Sand	31
ACKNOWLEDGMENTS	31
REFERENCES	31

FIGURES

Figure 1. Annual value of Utah energy and mineral production, inflation adjusted to 2022 dollars, 1960–2022	1
Figure 2. Select metal, industrial mineral, and coal production locations active in 2022 in Utah	2
Figure 3. Annual value of Utah mineral production in nominal dollars, 2008–2022	3
Figure 4. Utah mining economic indicators.....	5
Figure 5. Average annual mining employment and salaries in Utah	6
Figure 6. Production and value of select metals	8
Figure 7. Select metal and industrial mineral exploration and development activity locations in Utah	14
Figure 8. Utah aggregate production, 1950–2022	16
Figure 9. Production and value of potash and salt	17
Figure 10. Summary of Utah exploration statistics	24
Figure 11. Location and status of Utah coal mines and associated facilities.....	25
Figure 12. Location of active Utah coal mines and coalfields.....	26
Figure 13. Summary of annual coal end use statistics	28

TABLES

Table 1. Utah mining rankings and statistics	4
Table 2. Summary of metallic resource mining operations in Utah, 2022.....	7
Table 3. Select metal exploration and development projects in Utah, 2021	12
Table 4. Select industrial mineral exploration and development projects in Utah, 2022	20
Table 5. Coal production in Utah by coal mine, 2010–2023	27

UTAH MINING 2022

Metals, Industrial Minerals, Uranium, Coal, and Unconventional Fuels

by Andrew Rupke, Stephanie E. Mills, Michael D. Vanden Berg, and Taylor Boden

INTRODUCTION

2022 Utah Mining Industry Summary

The estimated combined value of Utah's extractive resource production in 2022 totaled approximately \$10.4 billion, including production of metals and industrial minerals (\$4.2 billion), natural gas and natural gas liquids (\$2.0 billion), crude oil (\$3.6 billion), and coal (\$504 million) (figure 1). Utah's diverse mining industry (metals, industrial minerals, and coal) accounted for \$4.7 billion (45%) of total extractive resource production, a slight decrease of \$61 million from 2021's revised value (nominal dollars) and lower than peak values reached in 2011 (\$5.2 billion, nominal dollars). Mining activities in Utah currently produce base metals, precious metals, industrial minerals, and coal (figure 2). Base metal production contributed \$2.1 billion and included copper, magnesium, beryllium, molybdenum, and iron (figure 3). Notably, copper alone accounted for 35% (\$1.6 billion) of Utah's mining production value and 16% of Utah's total extractive resource production value. Precious metals produced in Utah include gold and silver, and 2022 production was valued at \$300 million (figure 3). Precious metal production value decreased 25% from 2021 to 2022, primarily

due to less gold production, and base metal value decreased 7.7% due to a combination of factors. Industrial minerals produced in Utah include sand and gravel, crushed stone, salt, potash, cement, lime, phosphate, lithium, uintaite (Gilsonite®), clay, gypsum, and other commodities (figure 2). The estimated value of industrial mineral production in 2022 was \$1.7 billion (figure 3), a 13% increase over the revised 2021 estimate, driven in large part by increases in several commodity prices. The most valuable industrial mineral group in 2022, estimated at \$580 million, was the brine- and evaporite-derived commodity group which includes potash, salt, and magnesium chloride. The value of Utah coal production increased 5% in 2022 to \$504 million; production was lower in 2022, but the average price was much higher (figure 3). Notably, Utah remains the only state to produce magnesium metal, beryllium concentrate, potassium sulfate, and uintaite (Gilsonite®); of these commodities, magnesium metal and beryllium were included in the U.S. Geological Survey's (USGS) 2022 list of critical minerals (U.S. Geological Survey, 2022). Lithium, also considered a critical mineral, has been produced in Utah since 2020, making Utah one of only two lithium-producing states. Throughout this report, production is designated in US short tons (t) or million short tons (Mt) unless otherwise indicated.

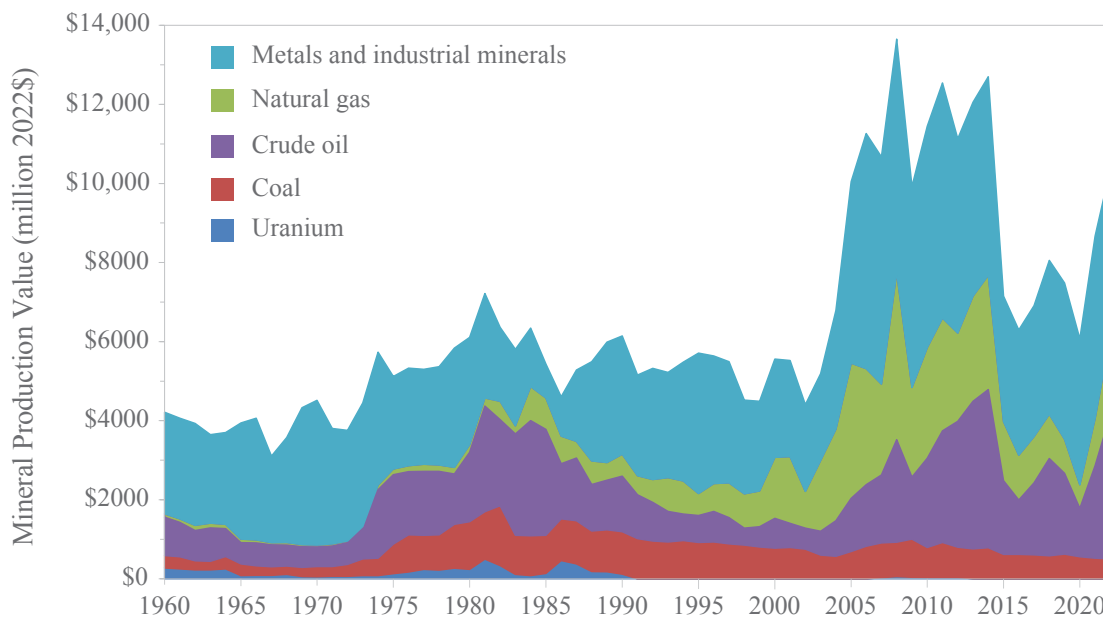


Figure 1. Annual value of Utah energy and mineral production, inflation adjusted to 2022 dollars, 1960–2022. Source: Utah Geological Survey; U.S. Geological Survey; Utah Division of Oil, Gas and Mining; U.S. Energy Information Administration; Utah Tax Commission.

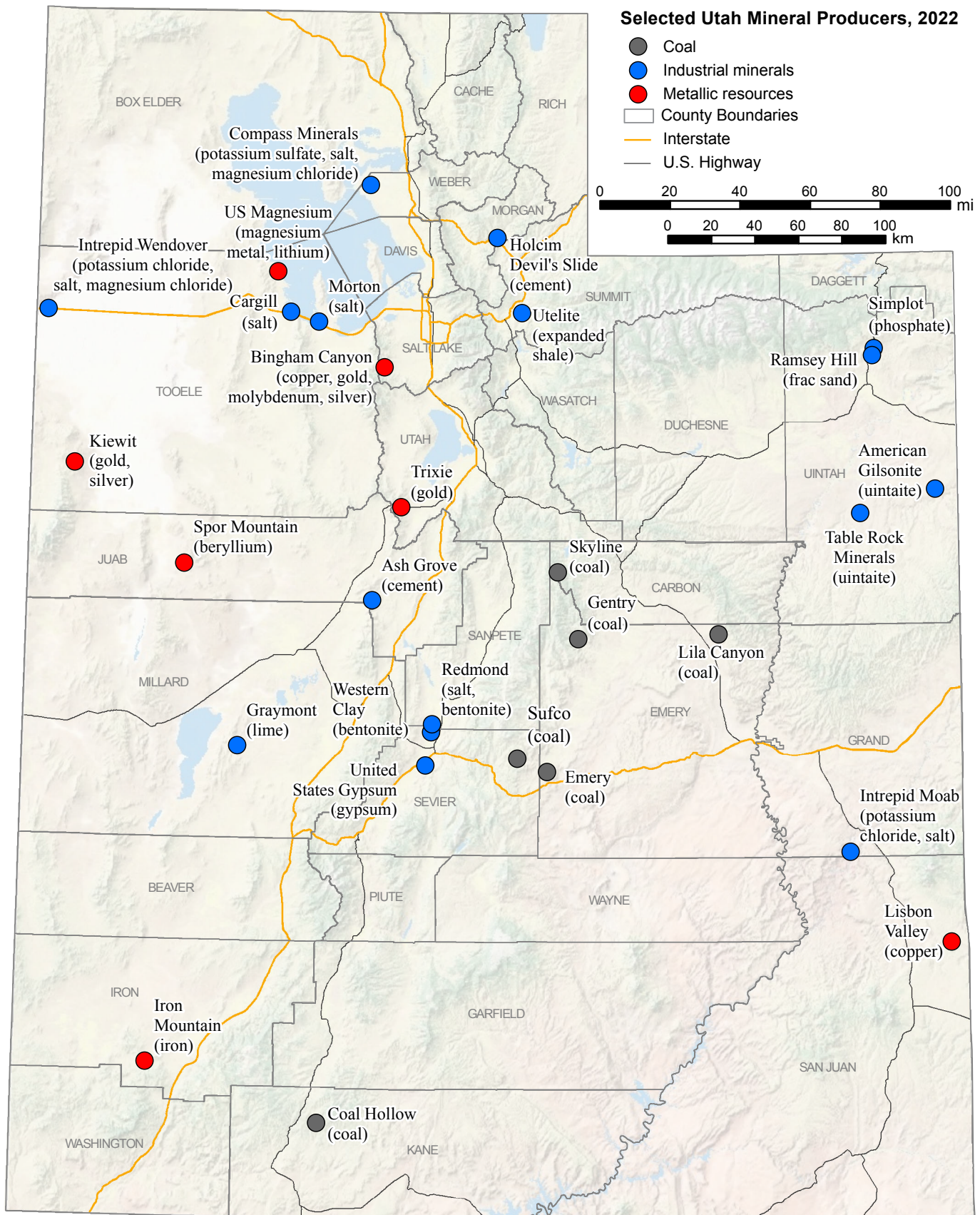


Figure 2. Select metal, industrial mineral, and coal production locations active in 2022 in Utah. Basemap provided by Utah Geospatial Resource Center (UGRC).

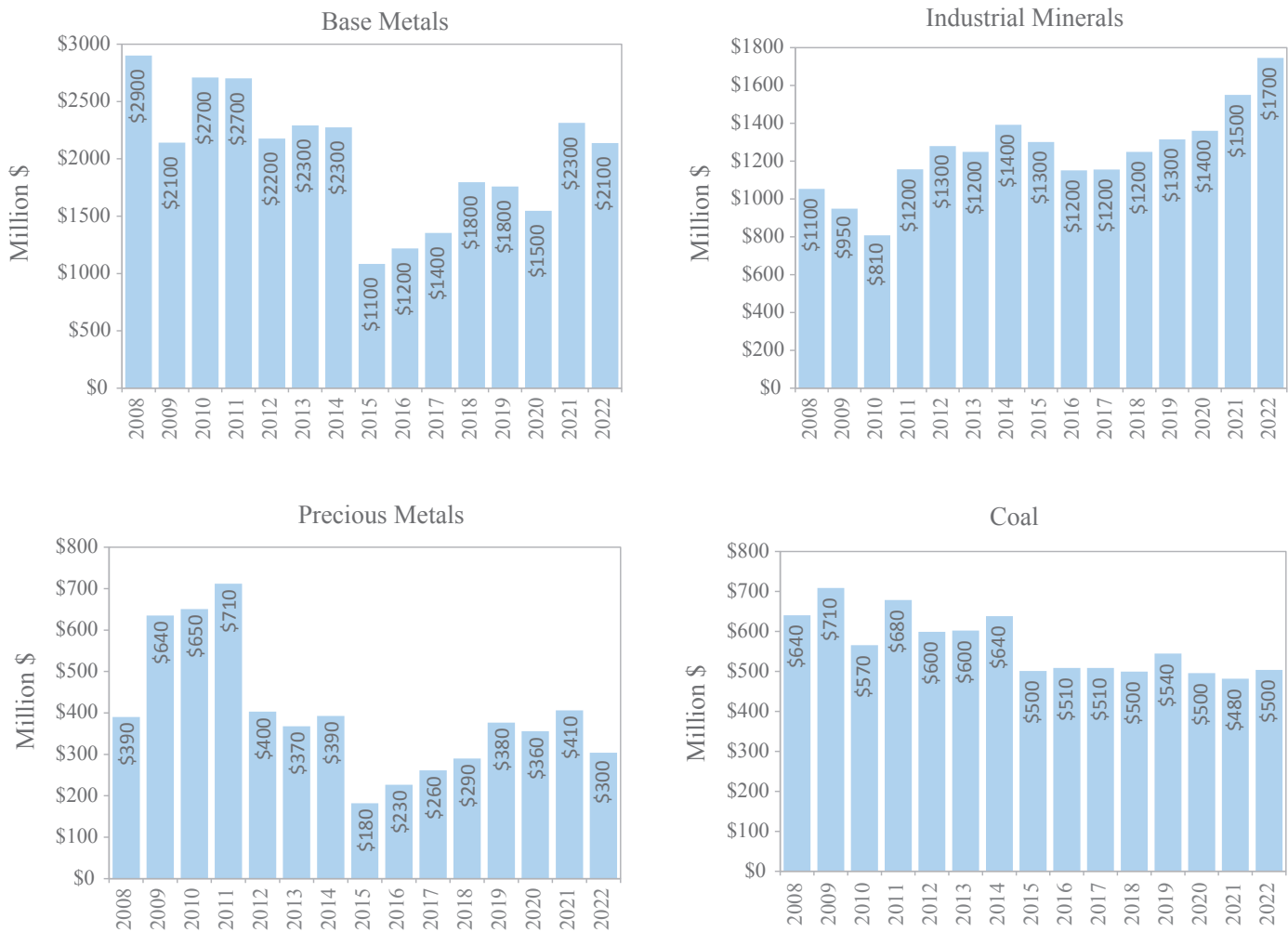


Figure 3. Annual value of Utah mineral production in nominal dollars, 2008–2022. Data source: Utah Geological Survey.

In 2022, the USGS ranked Utah as 8th nationally for production of nonfuel minerals (down one position from 2021), which include metals and industrial minerals (table 1). The USGS estimated Utah's nonfuel mineral production value at \$3.6 billion (compared to the Utah Geological Survey [UGS] estimate of \$4.2 billion), which accounted for 3.7% of the U.S. total, with copper, gold, potash, salt, and construction sand and gravel listed as principal commodities (U.S. Geological Survey, 2023a). Utah has ranked among the top 10 states for nonfuel mineral production for the past decade. In addition, Utah was the 12th largest coal producer of 21 coal-producing states in 2022 and accounted for 1.8% of total U.S. coal production (U.S. Energy Information Association [EIA], 2023a).

In the 2022 Fraser Institute annual survey of mining companies, Utah was ranked as the 17th most favorable state/nation out of 62 international jurisdictions for overall mining investment attractiveness (table 1) (Mejía and Aliakbari, 2023). This ranking represents a six-spot decrease from 2021, but remains within the range of previous rankings. The investment attractiveness index considers a combination of a region's geologic

favorability and the disposition of government policies toward exploration and development. Utah was again ranked the 5th most favorable jurisdiction in the United States behind Nevada, Colorado, Arizona, and Alaska.

The minerals regulatory program within the Utah Division of Oil, Gas and Mining (OGM) approved one large mine permit, four small mine permits, and ten exploration permits in 2022 (table 1). The large mine permit was issued for a frac sand mine in Uintah County and the small mine permits included three construction aggregate mines and one alabaster (gypsum) quarry. Eighteen exploration permits were approved for lithium (3), base and precious metals (2), construction aggregate (2), uranium (1), fluorspar (1), and oil sands (1) (Kim Coburn, OGM, written communication, April 2023).

The Utah School and Institutional Trust Lands Administration (SITLA), which manages about 3.4 million acres of state-owned lands in Utah, issued 74 new mineral leases in 2022, up from 68 in 2021 (table 1). These leases were issued for the following commodities: metalliferous minerals (47), sand and

Table 1. *Utah mining rankings and statistics.*

Utah mining ranking or statistic	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
USGS rank of U.S. nonfuel mineral production value (metals and industrial minerals)	7th	5th	8th	10th	8th	8th	7th	8th	7th	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	7th of 83	14th of 76	25th of 77	11th of 84	17th of 62
U.S. EIA rank for coal production by state	14th	13th	14th	10th	11th	12th	11th	10th	10th	12th
New OGM approved large mine permits	4	2	2	0	0	1	4	2	1	1
New OGM approved small mine permits	13	11	12	7	11	13	11	4	12	4
New OGM approved exploration permits	9	14	17	11	9	6	8	9	18	10
SITLA mineral leases issued	62	56	32	53	57	36	41	38	68	74
New BLM mining claims filed	2360	3110	975	5370	5710	5360	2280	3590	5060	8700
Total BLM mining claims (end of year)	19,500	19,800	18,500	21,500	21,900	23,000	21,600	23,100	28,000	20,400

Note: USGS = U.S. Geological Survey, EIA = U.S. Energy Information Administration, OGM = Utah Division of Oil, Gas and Mining, SITLA = Utah School and Institutional Trust Lands Administration, BLM = U.S. Bureau of Land Management

gravel (17), building stone (4), gemstone/fossil (3), potash (1), mineral salts (1), and clay (1) (Andy Bedingfield, SITLA, written communication, April 2023). Metalliferous mineral leases can include lithium and uranium.

In 2022, approximately 8700 new unpatented mining claims (based on unique serial numbers located in 2022) were filed on federal lands in Utah. In decreasing order, most of the new claims were in Grand, Millard, San Juan, Juab, Box Elder, and Tooele Counties, which all recorded over 500 new claims. Grand and Millard Counties were by far the standouts for the year, with each recording over 2000 new claims. The new claims in Grand County were likely due to a rush to stake prospective lithium, uranium, and vanadium prospects. In Millard County the high claim numbers were likely due to lithium interest in Tule Valley. At the end of 2022, there were approximately 20,400 active unpatented mining claims in Utah, which is a decrease from 2021's total, suggesting a large number of claims lapsed during the year (table 1).

Contributions by the Utah mining industry to the state tax base during 2021/2022 were significant (figure 4). The metal, industrial mineral (non-metal), sand and gravel, and coal mining industries paid over \$79 million in property taxes in 2021 (up 13% from 2020; calendar year; 2022 data will not be available

until August 2023) and over \$13 million in mining-related severance taxes in 2021 (down 7% from 2020; state fiscal year). Severance tax contributions increased slightly in 2022 to about \$16 million. All extractive industries, including oil and gas, paid nearly \$73 million in federal Mineral Lease disbursements in the 2022 state fiscal year. About 1.4% of Utah's gross domestic product came from the mining industry in 2022, 2.1% if oil and gas are included. Mining employment in Utah was up about 4% from 2021 to 2022, and had a wage increase of about 6% (figure 5).

Critical Minerals

In 2022, the USGS updated the federal critical mineral list to include 50 minerals (U.S. Geological Survey, 2022); the previous list from 2018 included 35 critical minerals (or groups of critical minerals) (Fortier and others, 2018). Critical minerals are defined as those necessary for economic or national security and have a supply chain vulnerable to disruption. A primary change in the number of critical minerals between versions is due to Platinum Group Elements (PGEs) and Rare Earth Elements (REEs) being grouped in the 2018 list whereas each PGE and REE has been listed as an individual critical mineral in the 2022 list. Mills and Rupke (2023) provided a detailed summary of critical minerals in Utah from the 2022 list.

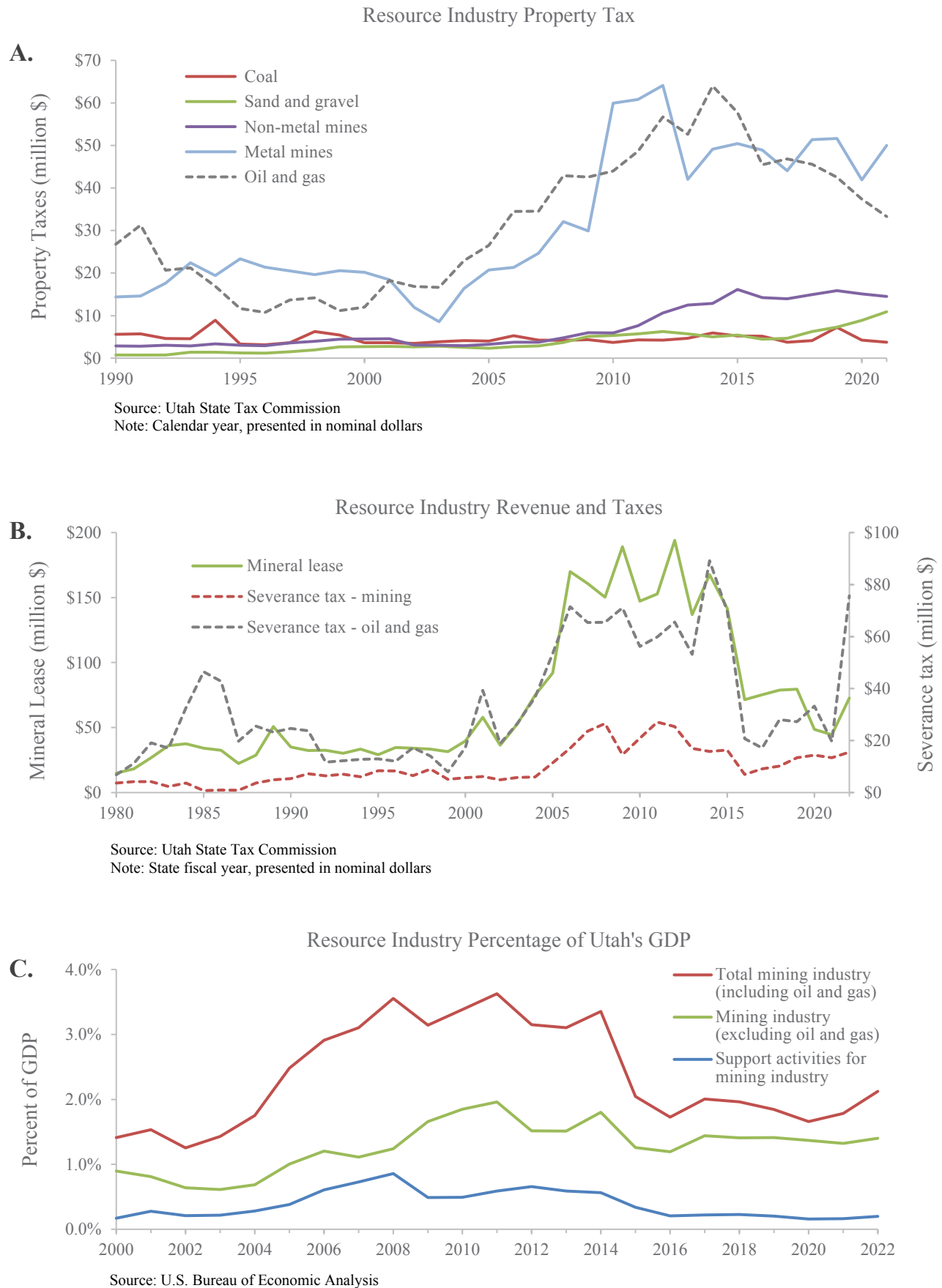


Figure 4. Utah mining economic indicators. (A) Property taxes charged against the mining industry, 1990–2021. (B) Mineral lease revenue and severance taxes, 1980–2022. (C) Percentage of Utah's gross domestic product (GDP) from mining-related activities, 2000–2022.

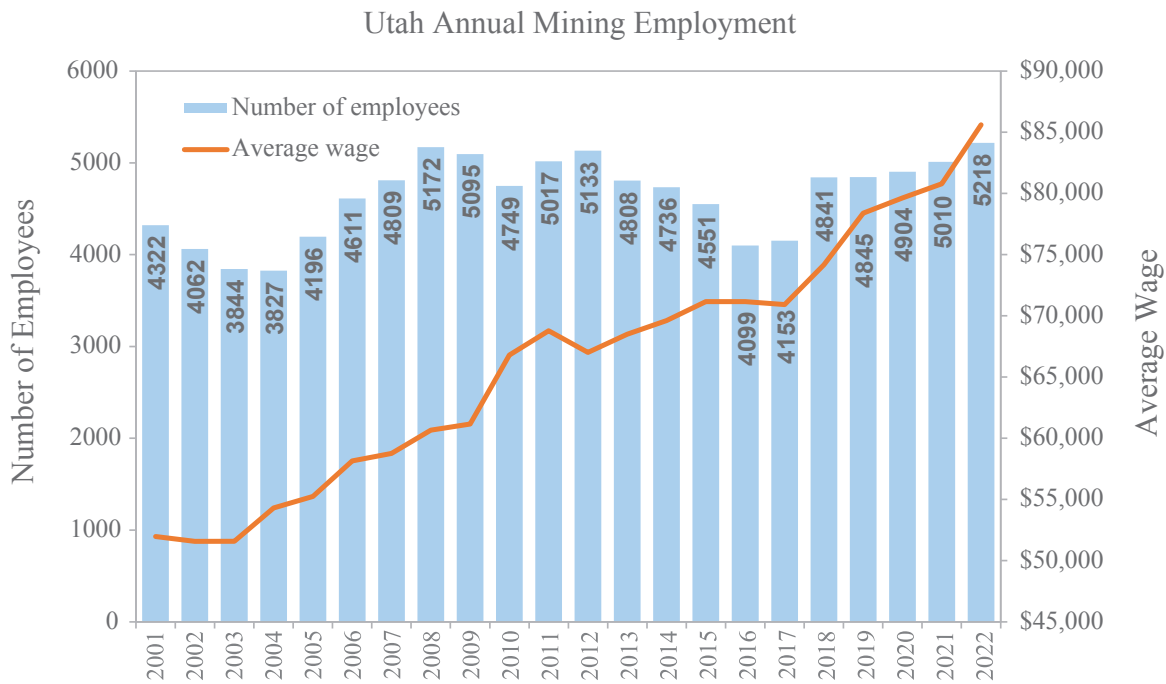


Figure 5. Average annual mining employment and salaries (in nominal dollars) in Utah. Includes metal, industrial mineral, and coal mines and facilities; excludes oil and gas. Source: Utah Department of Workforce Services.

In 2022, six critical minerals were produced in Utah (beryllium, lithium, magnesium metal, platinum, palladium, and tellurium). Fluorspar production is anticipated to begin in 2023. More details on these operations are given below.

- **Beryllium:** Utah is the only domestic producer of beryllium and is the global leader in the sector, with the Spor Mountain mining district in Juab County, owned by Materion Resources, producing 64% of global beryllium output in 2022 (U.S. Geological Survey, 2023a).
- **Lithium:** There are multiple established resources of lithium in Utah but the only production has been as a byproduct of magnesium metal production from Great Salt Lake brines by US Magnesium. Lithium was produced in Utah starting in 2020 and US Magnesium is working towards an annual production capacity of about 10,000 t of lithium carbonate equivalent (LCE).
- **Magnesium (metal):** Utah is the only domestic producer of magnesium metal, which is produced from Great Salt Lake brines via solar evaporation and electrolytic processing by US Magnesium.
- **Platinum and palladium:** Bingham Canyon, operated by Kennecott Utah Copper Company (a subsidiary of Rio Tinto), produces modest amounts of platinum and palladium as a byproduct of the precious metal refining process. The platinum and palladium are hosted in a crude selenium product and are not refined to pure elemental form.

- **Fluorspar:** Fluorspar (also known as fluorite) has historically been produced from the Lost Sheep mine in Juab County. The mine has been idle since the mid-2000s, but in 2020 Ares Strategic Mining began modern exploration to delineate the fluorspar resource and is currently developing a mine plan. Production is expected to begin in 2023. Once online, the Lost Sheep will be the primary domestic producer of fluorspar.
- **Tellurium:** Like platinum and palladium, tellurium is a byproduct of the Bingham Canyon mine. A new tellurium recovery plant was built in 2021 and initial production began in May 2022. Annual production capacity is estimated to be 22 t of tellurium (Rio Tinto, 2023), and Bingham Canyon is one of only two tellurium producers domestically.

In addition to the seven production-level critical minerals, Utah hosts known resources of six more (aluminum, indium, gallium, germanium, vanadium, and zinc) plus additional resources of lithium. More details on these deposits are given below.

- **Aluminum:** The Blawn Mountain deposit in Beaver County is the largest domestic alunite resource, hosting a measured and indicated resource of 150,000,000 t of alunite, which contains 56,000,000 t aluminum oxide and 32,000,000 t potassium sulfate (potash) in the alunite (Kerr and others, 2017).
- **Indium:** The West Desert deposit in Juab County is considered the largest indium deposit in the United

States; the deposit also hosts copper and zinc resources. American West Metals Limited is working towards a new indium resource estimate for the deposit, but previous estimates show a 1750 t indicated and inferred indium resource (Dyer and others, 2014), representing enough indium to supply U.S. imports for consumption for several years.

- **Lithium:** Lithium is being produced from Great Salt Lake as a byproduct of magnesium metal production on the western side of the lake, and an in-place resource of 2.6 Mt LCE has been demonstrated at the lake. Subsurface brines of the Paradox Basin are being explored through old oil and gas wells and thus far represent an indicated and inferred resource of 1.1 Mt of LCE.
- **Gallium and germanium:** The Apex mine in Washington County is estimated to contain roughly one million tons remaining ore containing approximately 330 t gallium and 850 t germanium (Krahulec, 2018), which would be enough gallium and germanium to supply U.S. consumption for many years.
- **Vanadium:** Mills and Jordan (2021) demonstrated there are still over 58,340,000 lbs vanadium pentoxide in known resources (historical and established) located in the Utah part of the Colorado Plateau, primarily the Paradox Basin. This value is likely to be an extreme underestimate as vanadium has historically not been quantified accurately due to the focus on uranium in these deposits. Currently, most exploration remains focused on uranium potential rather than vanadium.

- **Zinc:** The Burgin mine in Utah County is currently on care and maintenance and has an indicated and inferred resource of 100,000 t zinc (plus silver, gold, and lead). Based on a new resource estimate, the West Desert deposit in Juab County has an indicated and inferred resource of 1.4 Mt zinc (plus copper, indium, and other metals) (Stantec, 2023).

BASE AND PRECIOUS METALS

Production

2022 Utah Mineral Production Value Summary

Utah's total metalliferous resource production totaled \$2.4 billion in 2022, of which \$2.1 billion came from base metals and \$300 million came from precious metals. Overall, the production value of metalliferous resources decreased by 10% from 2021, largely driven by decreased production of gold, molybdenum, and magnesium metal. Table 2 summarizes metallic resource production in Utah, and the locations of active mines are shown on figure 2. Individual commodity updates are given below in order of decreasing mineral production value.

- **Copper:** The price of copper decreased by 5% from 2021 to 2022, and production increased by 12% (figure 6). Copper production increased due to higher production at the Bingham Canyon mine and continued production at the Lisbon Valley mine (operated by Lisbon Valley Mining Company). Production is expected to continue at current levels or slightly increase, given Bingham Canyon's mining shift to access higher

Table 2. Summary of metallic resource mining operations in Utah, 2022.

Operation	Owned By	County	Mining District	Copper	Gold	Molybdenum	Silver	Iron	Beryllium	Magnesium
Bingham Canyon	Kennecott Utah Copper Corporation (subsidiary of Rio Tinto Ltd.)	Salt Lake	Bingham	x	x	x	x			
Lisbon Valley	Lisbon Valley Mining Co.	San Juan	Lisbon Valley	x						
Trixie	Tintic Consolidated Metals Ltd.	Utah	East Tintic		x					
Kiewit	Desert Hawk Gold Corp.	Tooele	Gold Hill		x					
Iron Mountain	Utah Iron LLC	Iron	Iron Springs					x		
Spor Mountain	Materion Corp.	Juab	Spor Mountain						x	
Great Salt Lake	US Magnesium LLC	Tooele	n/a							x

grade copper ore. The price of copper is expected to remain strong in 2023, and the long-term outlook for copper is also strong given the importance of copper to electrification.

- Gold: Production of gold in Utah decreased by 25% from 2021, and the price remained flat at \$1800 per troy oz in 2022 (figure 6). Gold output from Bingham Canyon decreased by over 16,000 troy oz, production also decreased from both the Trixie mine, operated by Tintic Consolidated Metals, and the

Kiewit mine, operated by Desert Hawk Gold. The price of gold is anticipated to stay near or above current levels in 2023 given ongoing economic uncertainty and the war in Ukraine—geopolitical conflict and economic uncertainty have traditionally fueled gold's status as a safe-haven investment.

- Iron ore: Utah Iron operates the only iron mine in Utah, the Iron Mountain mine, which restarted at the end of 2020 and had significant production in 2021 and 2022. In 2022, production value decreased 25%, due

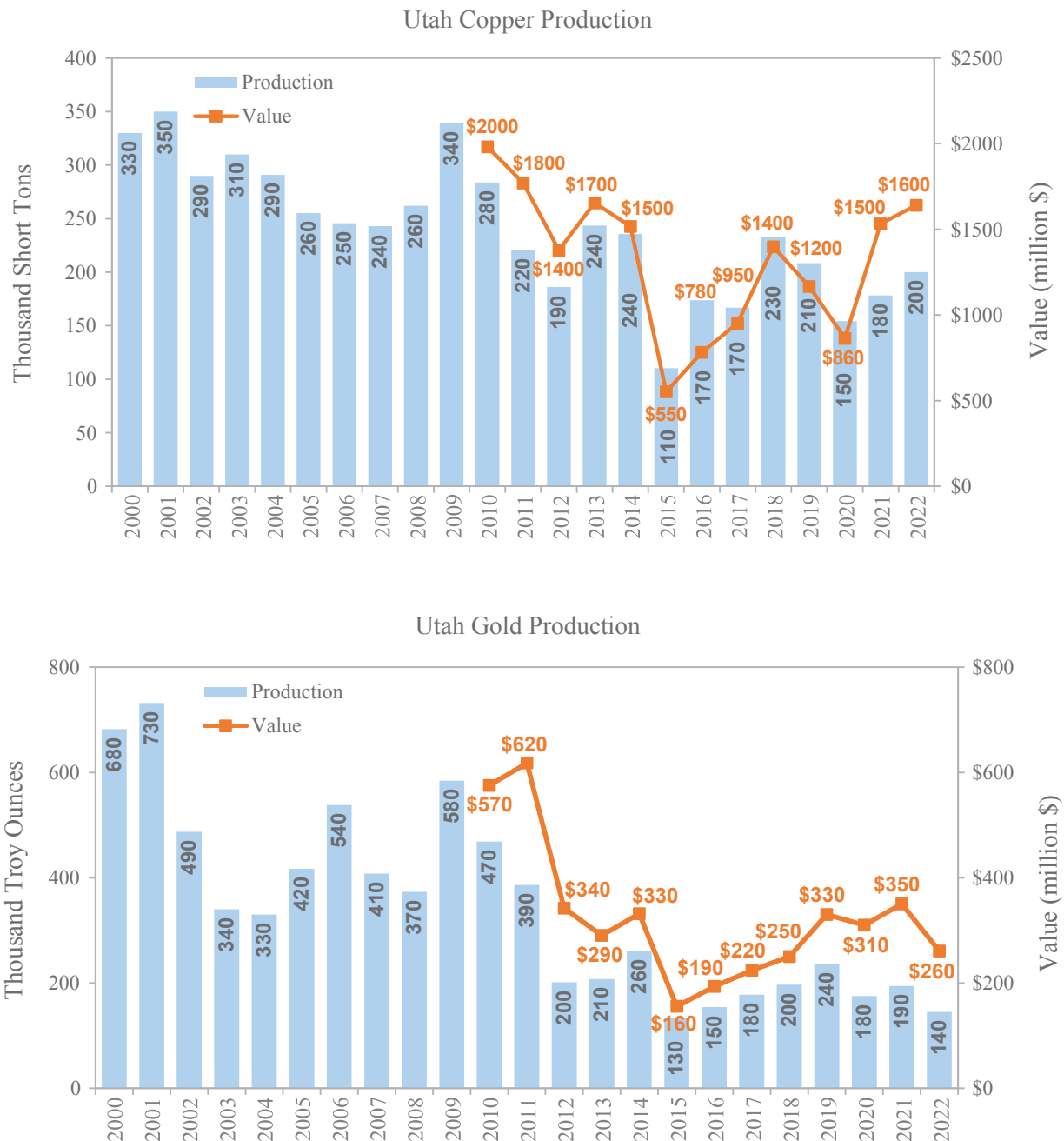


Figure 6. Production (since 2000) and value (since 2010) of select metals. Value in nominal dollars.

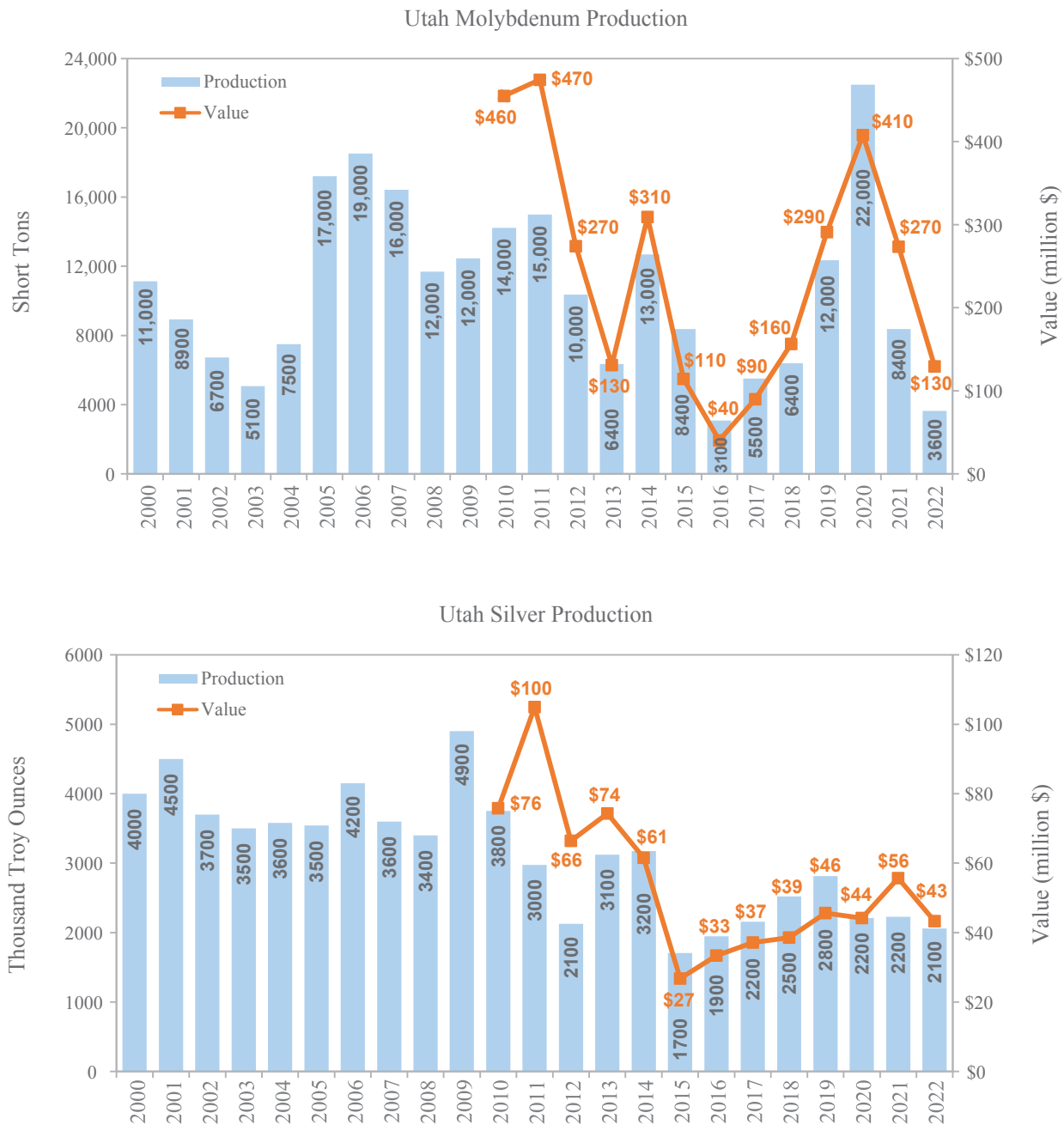


Figure 6. Continued.

to a 6% decrease in production and a 20% decrease in price. Iron production is expected to continue in 2023 and the price is expected to remain fairly stable.

- **Molybdenum:** Bingham Canyon was the only producer of molybdenum in 2022 and production decreased by 57% (figure 6). The price of molybdenum experienced a slight increase in 2022, so the overall decrease in mineral production value for molybdenum was 52%. The substantial decrease in production is due

to a previous ramp up in molybdenum production by Bingham Canyon in 2020 to offset the impact of suspended copper production during a period when the copper refinery was shut down. Bingham Canyon's focus returned to copper in 2021, hence the continued decrease in molybdenum production.

- **Beryllium:** Beryllium production and price from the Spor Mountain mining district remained relatively stable, yielding only a slight increase (4.7%)

in mineral production value from 2021 to 2022. Beryllium has been mined continuously from the Spor Mountain district since 1968 by Materion Resources, and proven and probable reserves can support a minimum mine life of 75 years at current mining rates (Materion, 2023).

- **Magnesium (metal):** The price of magnesium metal increased significantly (114%) from 2021 to 2022. However, production of magnesium metal by US Magnesium dropped significantly, resulting in an estimated mineral production value decrease of 51% from 2021 to 2022. Equipment failures at US Magnesium's plant are cited for the large decrease in both production and value, and also the large increase in the average annual U.S. spot price. Magnesium metal is produced by electrolytic conversion of magnesium chloride concentrate that is produced from Great Salt Lake brines through evaporation.
- **Silver:** Bingham Canyon, and to a lesser extent the Kiewit mine operated by Desert Hawk Gold, produced silver in Utah during 2022. Production levels decreased by 7.6% in comparison to 2021 (figure 6), and the price of silver decreased by 17% in 2022, hence mineral production value decreased by 23%. Silver production is expected to remain relatively stable, and the silver price is expected to remain strong given silver's dual role as a safe-haven investment and as a component in green energy technology (e.g., solar panels).

Utah Mining Updates for 2022

The Bingham Canyon mine accounted for 82% of Utah's total metalliferous mineral production value in 2022. Bingham Canyon produces copper, molybdenum, gold, and silver as well as byproducts such as platinum, palladium, lead carbonate, rhenium, and tellurium. It is outside the scope of this report to account for the mineral production value of Bingham's byproduct commodities.

Mining in Bingham Canyon shifted to the south wall in late 2020 and early 2021 following the first phase of the south wall pushback which has now been completed. The \$900 million investment extended the open-pit mine life to 2026. Waste stripping for a second \$1.5 billion phase of the pushback is underway and will extend current mine life to 2032. The shift to mining on the south wall accesses higher ($\geq 0.5\%$ Cu) and less variable copper grades. During 2022, Rio Tinto announced that it would begin development of underground mining at Bingham Canyon in an area called the Lower Commercial Skarn, which will allow an additional 33,000 t of copper to be mined through 2027 and will supplement ore from the open pit. Production of ore from this area was planned to begin in early 2023 and further development of

underground mining is expected in the future. In mid-2023, Rio Tinto also announced a \$500 million investment in development of the North Rim Skarn, another underground target, that will provide about 280,000 t of copper over ten years starting in 2024.

Other production updates for 2022 include:

- **Mining at Lisbon Valley:** Lisbon Valley Mining Company (LVMC) shut down mining activity at the Lisbon Valley copper mine in March 2020, causing release of their surety bond and loss of their active mining permit. LVMC re-permitted and re-bonded the operation in late 2020 and resumed open-pit mining at the Centennial pit in January 2021. Ore is processed on-site through heap leach and solution-extraction electrowinning to produce copper cathode. LVMC continues to pursue the permitting necessary to begin in situ recovery (ISR) mining at Lisbon Valley.
- **Production development at Trixie:** The Trixie underground gold mine restarted in late 2020 and had substantial production in 2021. Although production was lower in 2022, Osisko Development acquired Tintic Consolidated Metals to provide financing for further mine development and exploration. See "Utah Exploration Highlights" for additional details on the Trixie mine.
- **Magnesium metal production at Great Salt Lake:** During 2022, US Magnesium applied for an intake canal extension into Great Salt Lake due to historically low lake levels. The application was denied at the end of 2022 by the Utah Department of Environmental Quality based on insufficient information in the application. A significant rise in the lake level due to heavy precipitation during winter 2022–23 will provide some relief, at least in the short term, for mineral extraction companies on Great Salt Lake.

Exploration and Development

The information compiled in this section is from various sources, including the UGS annual survey of mine operators, the UGS annual exploration survey, mining company websites, press releases, technical reports, industry market research (e.g., S&P Global, 2023), and personal communication with industry geologists.

Budgets in the global minerals exploration industry for 2022 were influenced by a positive outlook emerging from the COVID-19 pandemic at the end of 2021. Junior explorers held nearly one-half of the global exploration budget, reaching an 11-year high. The minerals industry enjoyed an optimistic start to the year before inflation and recession concerns became apparent around mid-year. Exploration

budgets in 2023 will likely be lower than in 2022 because of the weaker commodities markets towards the end of 2022, with juniors likely to see the biggest decrease and majors expected to hold steady.

As in previous years gold is the leading commodity for global exploration budgets, followed by copper. Exploration allocations for lithium nearly doubled from 2021 and allocations in Utah also increased (see Lithium Exploration and Development section). By far, lithium is the most favored critical mineral for explorationists and significant exploration investments in other popular commodities such as cobalt or REEs have yet to materialize.

Near-mine and late-stage exploration still dominate exploration funding over greenfields projects. This trend was compounded by increased merger and acquisition activity in the mining sector, particularly in gold (e.g., ongoing interest by major miner Newmont in acquiring mid-tier miner Newcrest). Although the consolidation of exploration around mine sites and known resources makes sense in a short-term financial and shareholder view, it typically means mines will become larger and deeper with higher costs and have greater greenhouse emissions and operational risk.

Utah Exploration in 2022

Exploration drilling remained strong across the state in 2022, with 18 projects that drilled over 280,000 ft and 430 holes. This represents a modest increase from 265,000 ft drilled across 14 projects in 2021 and a significant increase over 2020 and 2019 when total drilling was between 55,000 and 65,000 ft (some bias may exist in earlier years due to increased reporting in 2021 and 2022). Notably, the amount of core drilling in 2022 increased from 2021. In 2022, approximately 35% of drilling was diamond core versus 17% in 2021. The Goldstrike project in Washington County conducted minor sonic drilling, which was the first time this technology was noted since UGS began tracking total state drilling footage in 2019. The 2022 uptick in drilling was not due to any single project or commodity, rather it was the accumulation of several projects intended to update or release a maiden resource in 2022 or 2023 as well as multiple projects in early stage testing. Two uranium companies also undertook notable drilling in 2022 (see the Uranium Exploration and Development section for more details).

Overall, 2022 was a strong year for the Utah exploration scene given the drilling activity described above and other field-based exploration activities across commodities and regions. The outlook for 2023 is a slight decrease in overall exploration activity, given that several projects released an updated or initial mineral resource estimate, which may result in a slowdown on drilling and shift to other development activity. However, many projects remain in the middle of the exploration arc and it is expected that exploration activities will remain diverse across the state through 2023.

Utah Exploration Highlights

The following section provides details on some of Utah's larger exploration programs during 2022. Information on additional exploration projects can be found in table 3 and figure 7. The information, table, and figure presented here are not an exhaustive list of all exploration being conducted in Utah, rather they represent significant exploration progress from companies who have made their projects public.

- **Deer Trail project, Piute County (Mount Baldy–Ohio district):** Deer Trail is a carbonate replacement deposit (CRD) and deep porphyry exploration project operated by MAG Silver via DT Mining LLC. In 2022 DT Mining completed a six-hole, 36,000-ft oriented diamond core program that intercepted a new sulfide feeder zone in the project, the Carissa zone, that included a 900-ft mineralized intercept averaging 12 g/t Ag, 0.2% Cu, 0.1% Pb, and 0.2% Zn (including individual sulfide zones containing highs of 266 g/t Ag, 1.5% Cu, 1.5% Pb, and 5.2% Zn). The sulfide lacing and skarn alteration in the Carissa zone is interpreted to be a different feeder zone than the main Deer Trail mineralization corridor, highlighting the potential for multiple overprinting mineralization events in the district. Approximately 16 miles of geophysics was also run in 2022 to help refine drill targets for the next phase of exploration.
- **Detroit project (including Mizpah, Drum, and Basin Complex targets), Juab and Millard Counties (Drum Mountain district):** Detroit is a distal-disseminated oxide gold project in the historic Drum Mountain area operated by Alderan Resources. In 2022, Alderan completed nine diamond holes for 3390 ft and 22 RC (reverse circulation) holes for 5895 ft, primarily over the Drum mine area. Drilling highlights include 2.9 g/t Au over 20 ft and 1.7 g/t Au over 68 ft, including 2.5 g/t Au over 21 ft, in the East Pit (historic Drum mine). Alderan is undertaking a review of all surface geochemistry, drilling, and gold recovery data to evaluate Detroit's overall potential prior to finalizing 2023 exploration plans.
- **Frisco project, Beaver County (San Francisco district):** The Frisco project is a deep porphyry target associated with breccia pipe and skarn mineralization explored under a joint venture between Kennecott Exploration (subsidiary of Rio Tinto) and Alderan Resources, with Kennecott as the controlling explorer. In 2022, Kennecott drilled two diamond holes totalling over 2700 ft. The first hole tested an area of the Cactus stock southwest of the historic Cactus mine and intercepted phyllic to potassic alteration with a highlight of 74 ft at 0.15% Cu; results are interpreted as indicative of a small, deep porphyry. The second hole tested an induced polarization anomaly

Table 3. Select metal exploration and development projects in Utah, 2021. Districts are shown on figure 7.

Project	Company ¹	Mining District ²	Commodity	County	2021 Activity
10 Mile Anticline	Atomic Minerals Corporation	Little Grand	U	Grand	Project acquired.
Calf Mesa	Anfield Energy Inc.	Calf Mesa	U	Emery	Project acquired.
Copper Warrior	American West Metals Ltd.	Lisbon Valley	Cu	San Juan	Field reconnaissance, rock chip sampling (yielding highs of 1.4% and 3.3% Cu), IP survey, and 3D inversion; large IP anomaly around historical pits identified. Maiden drill program planned for 2023.
Deer Trail*	DT Mining LLC (MAG Silver Corp.)	Mount Baldy-Ohio	Cu-Au	Piute	Completed 36,000-ft, 6-hole Phase 2 diamond drill program, discovered Carissa zone with 900-ft mineralized intercept averaging 12 g/t Ag, 0.2% Cu, 0.1% Pb, and 0.2% Zn (including up to 266 g/t Ag, 1.5% Cu, 1.5% Pb, and 5.2% Zn). Step out drilling planned for 2023.
Desert Mountain	Ivanhoe Electric (High Power Exploration Inc.; Little Sahara Exploration)	Desert Mountain	Cu-Au	Juab	Planned 2023 drill and exploration program based on 2021 exploration, which included 50 rock samples, 18 whole rock analyses, magnetic and gravity geophysics, and 2 RC drill holes intercepting low-grade Cu mineralization from surface.
Detroit*	Alderan Resources Ltd. (Volantis Resources Corp., Valyrian Resources Corp.)	Drum Mountains	Au-Cu-Mo	Juab	Drilled 9 diamond holes and 22 RC holes totaling over 9000 ft in the historic Drum mine area, including 2.9 g/t Au over 20 ft and 1.7 g/t Au over 68 ft, including 2.5 g/t Au over 21 ft, in the East Pit.
Drum Project	Golden Dragon Capital LLC	Drum Mountains	Au	Millard	Follow up on 2021 sampling; plans for WorldView-3 and SWIR ground studies in 2023.
East Canyon*	Uvre Ltd.	Dry Valley	U-V	San Juan	Project acquired; initial drill program of 11 holes (1595 ft) mixed RC and core at Nonesuch prospect and 5 holes (894 ft) mixed RC and core at Bonanza prospect, highlights include 7 ft at 0.12% U ₃ O ₈ and 5 ft at 1.0% V ₂ O ₅ in hole ECDD18 at Bonanza prospect (different intervals).
Energy Sands	Pegasus Resources Inc.	San Rafael River	U-V	Emery	Project acquired.
Frisco*	Alderan Resources Ltd. (Volantis Resources Corp., Valyrian Resources Corp.) and Kennecott Exploration Company (Rio Tinto)	San Francisco	Cu-Au-Mo	Beaver	Two diamond holes drilled totaling over 2700 ft; the first hole tested a mag high and geochem anomaly and intercepted 74 ft at 0.15% Cu, second hole tested an IP anomaly and intercepted mostly barren skarn.
Gold Springs*	Gold Springs Resources Corp. (TriMetals Mining Inc.)	Gold Springs	Au-Ag	Iron	Announced a resource update of 1,005,000 oz at 0.6 g/t Au equivalent based on 2021 drilling; completed over 55,000-ft RC and 2200-ft diamond drilling that expanded mineralization at North and South Jumbo and discovered Snow target; drilling highlights include 3.7 g/t Au equivalent over 30 ft at the North Jumbo resource.
Goldstrike	Liberty Gold Corp.	Goldstrike	Au	Washington	Completed metallurgical drill program of 12 diamond holes (4630 ft); 100 RC holes (27,700 ft) for resource definition, condemnation, and exploration; and 23 sonic holes (2670 ft) to determine gold contained in historical heap leach pads; 2023 plans to start formal pre-feasibility study.
Hart's Point	Atomic Minerals Corp.	White Canyon	U	San Juan	Project acquired and drill permitting initiated.
Lincoln	Ivanhoe Electric (High Power Exploration Inc.; Lincoln Cave Exploration Inc.)	Bradshaw	Polymetallic	Beaver	Optioned project from Grand Central Silver Mines; completed mapping, sampling, initial direct current resistivity and induced polarization (DCIP) geophysical survey over area 1.5 by 3.5 mi, and 3D inversion modeling to define targets for 2023 exploration program.
Lisbon Valley	Lisbon Valley Mining Company	Lisbon Valley	Cu	San Juan	Public comment periods on aquifer exemption permit for in situ leach and on mine plan modifications.
Lisbon Valley	Uravan Minerals Inc.	Lisbon Valley	U-V	San Juan	Project acquired; NI 43-101 released.

Table 3. Continued.

Project	Company ¹	Mining District ²	Commodity	County	2021 Activity
Main Tintic*	Ivanhoe Electric (High Power Exploration Inc.)	Main Tintic	Polymetallic	Juab	Ivanhoe Electric completed a \$169 million IPO in 2022; exploration prior to IPO from 2017 to 2021 included airborne and ground geophysics, geologic mapping, soil and rock sampling, age dating, petrology, compiling and digitizing old mine maps and historical core, re-logging and re-assaying historical core, 2 RC holes and 4 diamond holes, and a 25 sqmi 3D IP survey; initial 2022 diamond drilling started in November and will resume in 2023.
Marysvale	Anfield Energy Inc.	Newton	U	Beaver	Project acquired.
Mercur*	Ensign Minerals Inc. and Austral Gold Ltd.	West Dip, Mercur	Au	Tooele	Completed 37 RC holes (21,320 ft) and 10 diamond holes (5830 ft), highlights include 300 ft at 0.7 g/t Au in historical backfill and Mercur Member, and 25 ft at 1.2 g/t in the Lower Great Blue (EN070). Updated resource model expected in 2023.
Rattler	Okapi Resources Ltd.	La Sal	U	San Juan	Rock chip sampling (28 samples) returned up to 1.2% U ₃ O ₈ and 12.5% V ₂ O ₅ ; received approval for 100 shallow RC holes across Rattlesnake and Sunnyside prospects.
Southeast Utah (Tony M, Daneros, and Rim mines)*	Consolidated Uranium, Inc.	South Henry Mountains, Red Canyon, Dry Valley	U(-V)	Garfield, San Juan	Tony M: drilling completed on a planned 8-hole, 6000-ft RC and core program, updated indicated and inferred mineral resource published containing 8.8 Mlb U ₃ O ₈ equivalent; Daneros: drilling initiated on planned 8-hole, 7200-ft RC and core program; Rim: drilling initiated on planned 15-hole, 10,000-ft RC and core program.
Speedway	Moab Minerals Ltd.	Silver Island	Au	Tooele	Evaluation of drill targets following rock chip sampling, airborne magnetics, orthophotographic survey, and historical data acquisition projects.
Stateline	Alianza Minerals Ltd., Cloudbreak Discovery PLC, Allied Copper Corp.	Lisbon Valley	Cu	San Juan	Ongoing option negotiation to Allied Copper.
Thompson Knolls*	BCM Resources Corp. and Inland Explorations Ltd.	Kings Canyon	Cu	Millard	Completed two of nine planned holes in Phase 3 drilling, remaining holes underway; hole TK8 intercepted over 1000 ft of mineralized skarn (assays pending) and ended with mineralization still open. Remaining holes and assay results expected in 2023. BCM and Inland amalgamated in 2022 and will operate under BCM.
Trixie and East Tintic*	Tintic Consolidated Metals LLC and Osisko Development Corp.	East Tintic	Au-Cu	Juab/Utah	Acquisition of TCM by Osisko completed; initial resource estimate for Trixie mine released containing 456 koz Au and 915 koz Ag; completed 28 RC holes (27,700 ft) and 62 diamond holes (10,060 ft); nearly 1000 chip samples from 230 mine faces with assay values in excess of 5000 g/t Au.
Valley-Crossroads	Alderan Resources Ltd. (Volantis Resources Corp., Valyrian Resources Corp.) and Tamra Mining LLC	Rocky/Beaver Lake	Cu-Au	Beaver	Alderan withdrew from option agreement with Tamra Mining following 2021 exploration results.
Vanadium King	Thor Mining Plc (American Vanadium Pty Ltd, Cisco Minerals Inc.)	Thompson	U-V	Grand	Planned initial drilling, magnetics, and radiometrics programs to commence in 2023
West Desert*	American West Metals Ltd.	Fish Springs	Zn-Cu-In	Juab	Completed 7 hole program totaling 14,680 ft, highlights include 20 ft at 10.7% Zn, 4.3 g/t Ag, 54.0 g/t In and 56 ft at 1.0% Cu, 0.6 g/t Au, 12.5 g/t In; updated mineral resource of 1.4 Mt Zn, 54,000 t Cu, and 10 Moz Ag; completed metallurgical testing of Zn and Cu recoveries from oxide and sulfide zones.
West Tintic	Cerberus Venture LLC	West Tintic	Au	Juab	Acquired WorldView-3 imagery and conducted mapping and SWIR-based vectoring study to identify porphyry and CRD targets under cover.
Wray Mesa	Basin Uranium Corp.	La Sal	U-V	San Juan	Project acquired, 49 holes permitted; initial drill program planned for 2023.
Yellow Cat	Anson Resources Ltd. (Blackstone Resources Inc.)	Thompson	V-U	Grand	Pursued permitting for exploration drilling program to confirm existing drill results and extend known mineralization.

¹Parentheses indicate alternative or previous company names.²As defined in Krahulec (2018).

*More detail on these projects provided in the text.

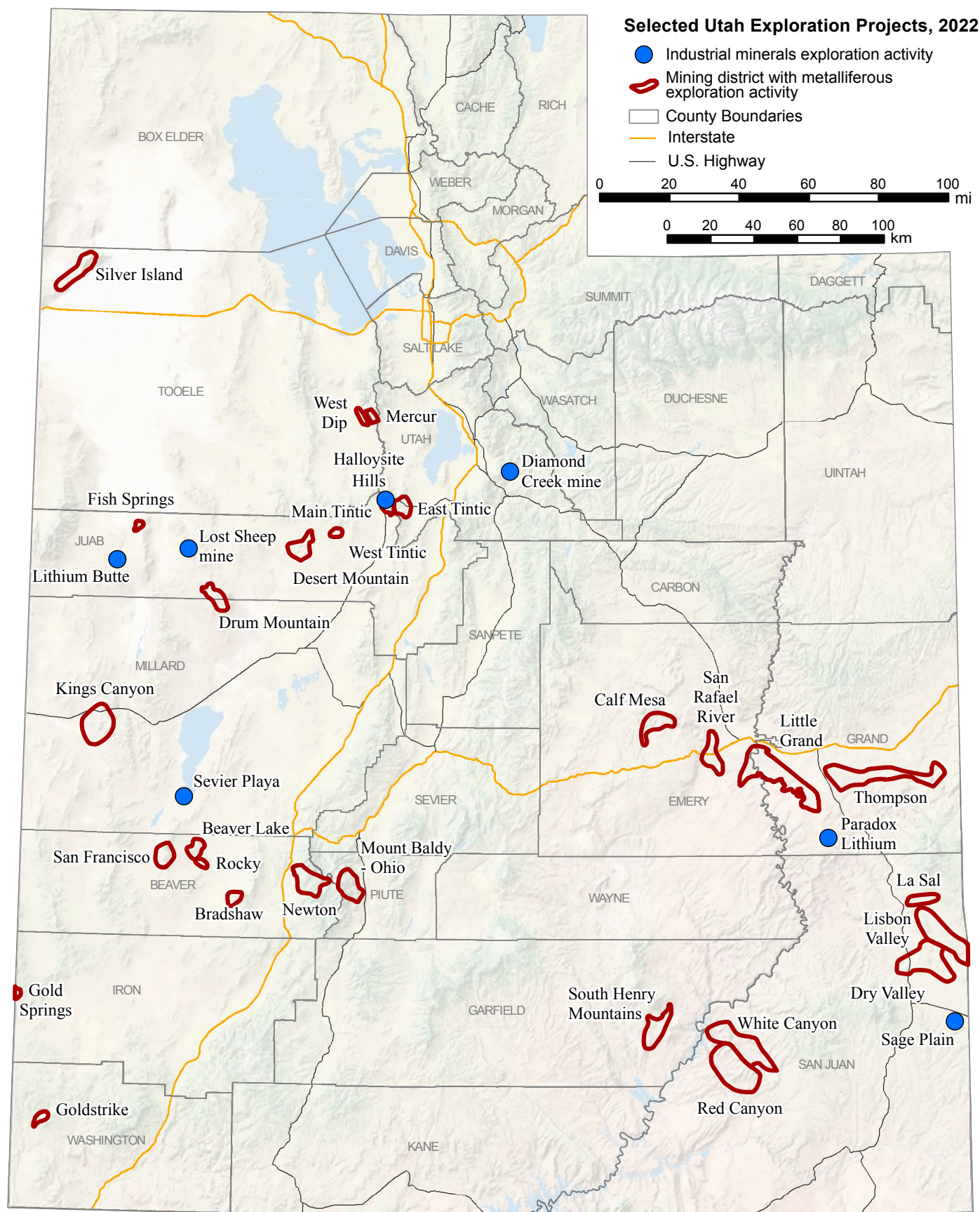


Figure 7. Select metal and industrial mineral exploration and development activity locations in Utah. Basemap provided by Utah Geospatial Resource Center (UGRC).

near the historic Washington and Imperial mines and intercepted mostly barren skarn, interpreted to be the result of low-grade metasomatism associated with the Cactus stock rather than a buried porphyry target.

- **Gold Springs deposit, Iron County (Gold Springs district):** Gold Springs is a low sulfidation epithermal gold project that straddles the Utah-Nevada border operated by Gold Springs Resources Corp (GRC). In 2022, GRC announced a resource update of 1,005,003 oz Au equivalent at a grade of 0.6 g/t Au equivalent based on updates from the 2021 drilling campaign. Drilling in 2022 included over 55,000 ft of RC and 2200 ft of diamond drilling on the Utah side of the project that delineated mineralized extensions to the North and South Jumbo areas and a new mineralized zone discovery at the geophysics-based Snow target. Drill highlights in 2022 include 1.9 g/t Au equivalent over 95 ft, including 3.7 g/t gold equivalent over 30 ft (North Jumbo), 0.7 g/t gold equivalent over 85 ft (South Jumbo), and 2.0 g/t gold equivalent over 10 ft (Snow).
- **Main Tintic, Juab County (Main Tintic district):** Main Tintic is a CRD and porphyry-prospective district held by Ivanhoe Electric. In 2022, Ivanhoe completed a \$169 million initial public offering and became a publicly listed company on the NYSE American and Toronto Stock Exchange. Previously unreported exploration in the district from 2017 to 2021 included airborne and ground geophysics, geologic mapping, soil and rock sampling, age dating, petrology, compiling and digitizing old mine maps and historical core, and re-logging historical core. An initial drill program took place in 2021 consisting of two RC holes and a diamond wedge program of four fan holes. Ivanhoe also flew their proprietary Typhoon 3D IP survey over approximately 25 square miles. In 2022, exploration consisted mainly of re-assaying historical holes, interpreting previous exploration results, and planning the second phase of diamond drilling, which started in November 2022 and is expected to be completed in early 2023.
- **Mercur project, Tooele County:** The Mercur project (which includes the historic Mercur mine, the greater Mercur district, and the West Dip project) is a Carlin-type gold project operated by Ensign Minerals. Exploration activities in 2022 included a 37-RC-hole (21,320 ft) and 10-diamond-hole (5830 ft) program. Some assays are still pending, but current highlights include 300 ft at 0.7 g/t Au in historical backfill and the Mercur Member plus 25 ft at 1.2 g/t in the Lower Great Blue (EN070), demonstrating continued upside potential for additional mineralized zones in the Great Blue Limestone (as opposed to traditional models that limit mineralization to the Mercur Member). Diamond drilling further characterized a complex, steeply dipping fault zone with associated brecciation and oxidation. An updated resource model is expected in 2023.
- **Thompson Knolls project, Millard County (Kings Canyon district):** Thompson Knolls is a porphyry copper target explored by BCM Resources Corp. In 2022, BCM initiated a nine-hole Phase 3 drilling program, with two diamond holes reported to date. Hole TK-8 intercepted an exceptionally long interval of visually mineralized skarn starting at approximately 2000 ft downhole and extending another 1000 ft until the hole was lost. The hole ended in mineralization. The diopside-marble skarn is characterized by magnetite-sulfide breccia with zones that were up to 20% chalcopyrite by volume. Assays and remaining hole results are expected in 2023. BCM Resources and Inland Exploration, the two companies involved in the Thompson Knolls project, combined under the BCM Resource name in late 2022.
- **Trixie mine, Juab and Utah Counties (East Tintic district):** The acquisition of Tintic Consolidated Metals by Osisko Development was announced in early 2022 and completed by mid-year. Following the acquisition, Osisko undertook an aggressive exploration program centered on the Trixie mine that included 28 surface RC holes (27,700 ft) to the north and west of Trixie and 62 underground diamond holes (10,060 ft) from the 625 mine level expanding along the T2 and T4 structures. Not all assays have been reported, but highlights to date include 12.6 g/t Au and 440 g/t Ag over 17 ft in underground drilling. In addition to drilling, nearly 1000 chip samples were taken from over 230 mine faces and multiple samples reported in excess of 1000 g/t Au, with the highest values exceeding 5000 g/t Au. Drill and chip results went into an initial mineral resource estimate for Trixie with a measured, indicated, and inferred resource containing 456,000 oz Au and 915,000 oz Ag. Exploration in 2023 will focus on extending known mineralization around Trixie as well as developing regional epithermal, CRD, and porphyry targets throughout the East Tintic district.
- **West Desert deposit, Juab County (Fish Springs district):** West Desert is a zinc-copper-silver-indium skarn resource explored by American West Metals Limited. The 2022 exploration program comprised seven diamond holes totaling 14,680 ft with highlights including 20 ft at 10.7% Zn, 4.3 g/t Ag, and 54.0 g/t In, and 56 ft at 1.0% Cu, 0.6 g/t Au, and 12.5 g/t In, both in WD22-05. American West also released an updated mineral resource for the deposit, which was the first update since 2014 (Dyer and others, 2014). The new resource represents a 44% value increase over the previous iteration. The indicated and inferred resource, including both open-pit and underground resources, contains 1.4 Mt Zn, 54,000 t

Cu, and 10 Moz Ag. Indium, which was included in the 2014 resource estimate, was not included in this resource due to lack of historical assays, but resampling is underway to include indium in future resource estimates. American West also carried out metallurgical testing of Zn and Cu recoveries from oxide and sulfide zones of the deposit.

INDUSTRIAL MINERALS

Production

Industrial mineral production in Utah during 2022 had an estimated value of \$1.7 billion, which was 13% higher than the revised 2021 value (figure 3). The largest contributor was the potash, salt, and magnesium chloride group, which are all brine- and evaporite-derived commodities. These products had a combined value of \$580 million in 2022 (a 27% increase from 2021) and accounted for 33% of the industrial mineral total. The second largest contributor was the construction aggregate (sand and gravel, crushed stone) and dimension stone group. These products had a combined value of \$560 million (a 14% increase from 2021) and accounted for 32% of Utah's total industrial mineral production value in 2022. The third-largest contribution to the value of industrial minerals production came from the Portland cement, pozzolan, lime, and limestone product group. These products had

a combined value of nearly \$290 million in 2022, a 2.6% increase from 2021, and accounted for 17% of the total industrial mineral value. Together, these three commodity groups contributed 88% of the total 2022 value of industrial minerals produced in Utah. The remaining value came from phosphate, uintaite, clay and shale, silica and industrial sand, lithium, and gypsum.

Sand and Gravel, Crushed Stone, and Dimension Stone

Sand and gravel, crushed stone, and dimension stone are produced by many private and government entities. Given the numerous producers of this commodity group, the UGS does not survey all the operators. However, the UGS compiles data from selected operators and uses USGS data for production and value estimates. During 2022, approximately 39 Mt of sand and gravel was produced in Utah, which was 6.8% less than the revised 2021 production estimate, and was worth \$390 million (U.S. Geological Survey, 2023b). About 13 Mt of crushed stone worth \$160 million (U.S. Geological Survey, 2023b) represented an 11% production decrease from revised 2021 estimates. Several thousand tons of dimension stone was also produced. Sand and gravel and crushed stone are construction aggregates used in applications such as concrete aggregate, asphalt aggregate, and road base. A strong construction market in Utah has kept construction aggregate demand relatively high for the past several years (figure 8).

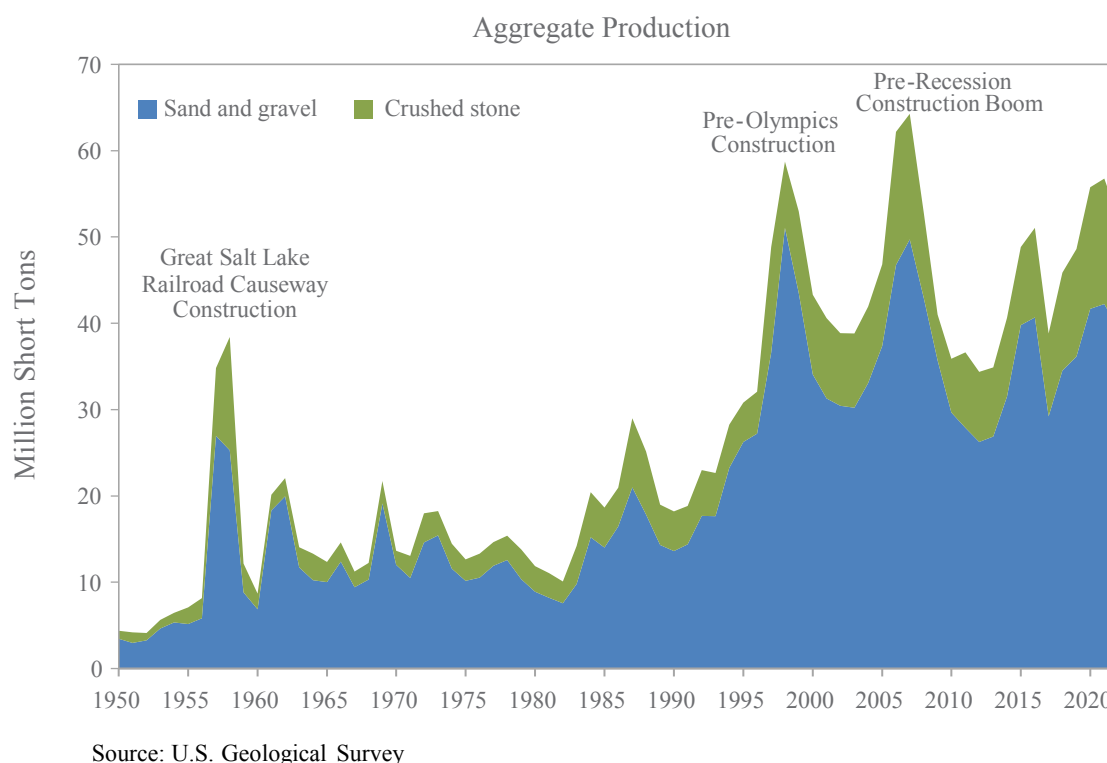


Figure 8. Utah aggregate production, 1950–2022.

Potash, Salt, and Magnesium Chloride

The brine- and evaporite-derived commodities produced in Utah include potash, salt (NaCl), and magnesium chloride. Potash is produced as potassium sulfate (sulfate of potash or SOP) and potassium chloride (muriate of potash or MOP). Potash production in Utah totaled 390,000 t and was valued at approximately \$310 million in 2022 (figure 9). Compass Minerals 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 targeting deep, subsurface evaporites of the Pennsylvanian-age Paradox Formation (figure 2). Potassium sulfate generally has a higher (+\$130 per ton in 2022) market value than potassium chloride, but the primary use of both types of potash is fertilizer. Potash prices rose dramatically during 2022; SOP price rose about 37% and MOP price rose over 100%. The increase in potash price was due to the war in Ukraine, as Russia and Belarus are among the top global potash producers.

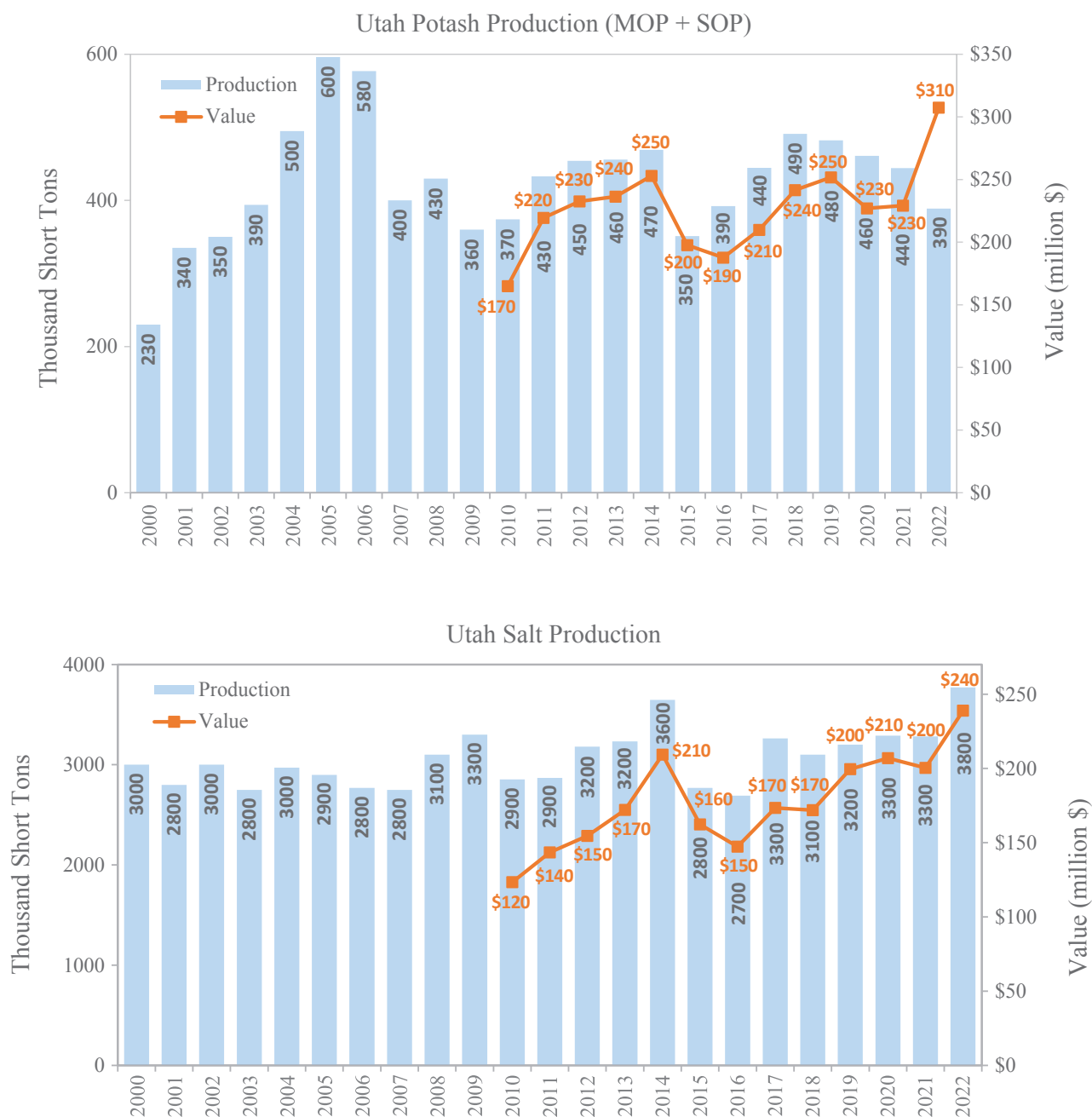


Figure 9. Production (since 2000) and value (since 2010) of potash (all types) and salt. Values in nominal dollars. Data source: Utah Geological Survey.

About 3.8 Mt of salt was produced in Utah in 2022, with an estimated production value of \$240 million (figure 9). Salt production was about 15% higher than 2021, but this increase is partly due to inclusion of byproduct salt that we have not reported before. About 84% of the salt was produced from Great Salt Lake brine by four operators: Compass Minerals, Cargill Salt, US Magnesium, and Morton International (figure 2), in descending production order. The remainder was from Redmond Minerals, Intrepid Potash-Moab, Willow Creek Salt, and Intrepid Potash-Wendover (in descending production order). Redmond Minerals operates an underground mine near Redmond in Sanpete County (figure 2) that produces salt from the Jurassic-age Arapien Shale. Willow Creek Salt operates a surface mine east of Redmond that also produces salt from the Arapien Shale and recently converted their small mine permit to a large mine permit with OGM. Salt produced in Utah is used for various purposes including road deicing, water treatment, agricultural supplements, and industrial applications. Redmond Minerals and Morton International also produce food-grade salt from their respective facilities at Redmond and Great Salt Lake.

In 2022, magnesium chloride brine production in Utah increased slightly to 860,000 t and had an estimated production value of about \$33 million. The magnesium chloride brine was produced by Intrepid Potash-Wendover and Compass Minerals; the latter also produced 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 3.6 Mt of total material was produced from Great Salt Lake brine in 2022, including salt, potash, magnesium chloride, and magnesium metal. Production in 2022 was slightly higher than our revised 2021 estimate. These estimates do not account for all byproducts, such as chlorine gas, so the actual total production was slightly higher. The estimated value of mineral and brine production (including salt, potash, magnesium chloride, magnesium metal, and lithium carbonate) from Great Salt Lake in 2022 was about \$540 million.

Portland Cement, Pozzolan, Lime, and Limestone

Together, Ash Grove Cement and Holcim produced about 1.8 Mt of Portland cement in Utah during 2022, having an estimated value of \$210 million. Ash Grove Cement operates the Leamington quarry and plant east of Leamington in Juab County, and Holcim operates the Devil's Slide quarry and plant east of Morgan in Morgan County (figure 2). Portland cement production and value have been fairly stable for the past several years. Besides limestone for Portland cement, Ash Grove and Holcim also produce smaller amounts of sandstone, clay, and shale, which supplement their limestone feedstock at their cement plants.

Pozzolan materials are typically high in silica and alumina and have cementitious properties that are useful to extend and/or enhance portland cement. Other benefits of pozzolans over conventional cement production can include reduced manufacturing cost and reduced greenhouse gas emissions. Geofortis is producing pozzolan at their mine in Rush Valley at Faust, Tooele County. Their pozzolan resource is a tephra (volcanic ash) in the Tertiary-age Salt Lake Formation. In 2021, they expanded an existing small mine permit with OGM from 5 to 20 acres and also completed a processing plant in Tooele. Geofortis continues to expand and we estimate that they roughly doubled their pozzolan production from 2021 to 2022.

During 2022, Graymont Western U.S. remained the sole producer of lime in Utah and increased their production by about 3.3%. Graymont 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.

In Utah, limestone is produced for both crushed stone and for specialty purposes. Limestone produced for crushed stone is used for common construction aggregate and is included in the sand and gravel, crushed stone, and dimension stone commodity group tally. During 2022, several million tons of limestone was produced for specialty purposes; most of this production was used to manufacture cement and lime (discussed above). However, 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 major phosphate producer in Utah and mines ore from the Meade Peak Member of the Permian-age Phosphoria Formation. Their phosphate operation is located 12 miles north of Vernal in Uintah County (figure 2). In 2022, the mine produced nearly 3.4 Mt of ore. The ore yielded about 1.3 Mt of phosphate concentrate (about 30% P_2O_5) after processing, which is a 9.4% decrease from 2021. The concentrate is transported in slurry form 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 (U.S. Geological Survey, 2023a).

Since 2020, phosphate has also been produced at the Diamond Creek mine near Diamond Fork in Utah County (figure 7). Keras Resources operates the mine which produced several

thousand tons of organically certified phosphate in 2021 and 2022. Their plan is to extract a few thousand tons of phosphate rock per year from a roughly 7-ft-thick zone of the Meade Peak Member of the Permian-age Phosphoria Formation. The area was last mined for phosphate around 1980.

Uintaite (Gilsonite®)

Uintaite (also spelled “Uintahite” and commonly referred to as Gilsonite, which is a trademarked name) 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 with some minor production in the Colorado part of the basin. In 2022, American Gilsonite Company was the primary uintaite producer, with mining and processing at their operation in southeastern Uintah County (figure 2). Table Rock Minerals, LLC also produced uintaite at the TRM #1 mine that is on a SITLA lease in the Uinta Basin south of Ouray in Uintah County. The mine began operating in 2018 and has the capacity to extract about 10,000 t of uintaite per year. The mine is in the Cottonwood vein.

Over the past several years, uintaite production from the Uinta Basin has ranged up to about 85,000 t per year, depending on market conditions (specific production and price data are proprietary). Utah is the only place in the world that contains large deposits of uintaite, 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 uintaite as an additive in drilling fluids. Uintaite helps control fluid loss and seepage, increase wellbore stability, prevent loss of circulation, and stabilize shale formations.

Clay and Shale

Several hundred thousand tons of clay and shale were produced in Utah in 2022 including bentonite, common clay, high-alumina clay, and expanded shale. Clay is produced at various small and large mines, often on an intermittent basis. Consequently, year-over-year production and value estimates are subject to significant change. Some of the largest producers of clay and shale products are Utelite (expanded shale), Interstate Brick (common clay), Ash Grove Cement (high-alumina clay), and LafargeHolcim (high-alumina clay). Bentonite was produced by Western Clay and Redmond Minerals in central Utah (Sanpete and Sevier Counties). Notably, Redmond Minerals acquired Western Clay in 2021. Uses for bentonite include well drilling and foundry operations, various civil engineering applications, and as litter-box filler. Common clay is largely used to make bricks, whereas most high-alumina clay from Utah is used to make portland cement. Applied Minerals Inc. intermittently produces a small amount of specialty clay (halloysite) and iron oxide from the Dragon mine in the Tintic Mountains. They have been researching potential applications and markets for halloysite over the past several years.

Expanded shale in Utah is produced by Utelite at their quarry and plant near Wanship in Summit County (figure 2). Expanded shale is a lightweight aggregate, sometimes called “bloated shale,” mainly used by the construction industry. It 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 roofing tile, concrete block, structural concrete, and horticultural additives, as well as for highway construction and geotechnical fill. Roughly half of Utelite’s production is used locally along the Wasatch Front and the rest is shipped out of state. In 2021, LafargeHolcim acquired Utelite, and the operation will be part of their aggregates division.

Silica and Industrial Sand

Silica and industrial sand production in Utah during 2022 had an estimated value of about \$78 million. Production of these commodities increased by about 160% from 2021 to 2022. On Stansbury Island, Bolinder Resources mines quartzite from the Devonian-Mississippian-age Stansbury Formation as a source of industrial silica that is used as a flux at the Kennecott smelter. Some of the quartzite is also used as construction aggregate. North of Vernal, Ramsey Hill Exploration produces frac sand from unconsolidated Quaternary mixed alluvial and eolian deposits (figure 2). Frac sand is relatively pure silica sand that is used for hydraulic fracturing stimulations in oil and gas wells, and Ramsey Hill is supplying this sand for local use in the Uinta Basin. They began production in late 2019. In 2022, Ramsey Hill completed a large mine permit with OGM that will allow them to mine the Triassic-Jurassic-age Nugget Sandstone that is adjacent to the Quaternary-age unconsolidated deposits as an additional source of sand. A large fraction of the sand in the unconsolidated deposits is likely derived from the Nugget Sandstone.

Gypsum

Four operators reported combined gypsum production in Utah of about 790,000 t in 2022, a slight 2% increase from the 2021 reported production. The estimated value of 2022 gypsum production is \$11 million. The four Utah gypsum producers were Progressive Contracting, Inc., Sunroc Corp., United States Gypsum Co., and Diamond K Gypsum (in descending production order). Utah gypsum is commonly 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 higher value calcined gypsum are used to make wallboard by United States Gypsum, which operates a wallboard plant near Sigurd in Sevier County (figure 2). Diamond K Gypsum received approval from OGM in 2021 for a 160-acre expansion of their Chalk Hills Quarry in the northwest part of the San Rafael Swell in Emery County. Their mine plan

anticipates an annual production of about 34,000 cubic yards of gypsum for about 28 years. Diamond K mines gypsum from the Jurassic-age Carmel Formation and they report that their ore zone ranges from 5 to 25 ft thick, including lenses of waste rock. The San Rafael Swell is known to have large, pure gypsum resources (Rupke and Boden, 2013).

Lithium

Utah entered its third year of lithium production in 2022. US Magnesium has worked towards producing lithium as a by-product for many years (Tripp, 2002) and commercial production began in 2020. Lithium is concentrated along with magnesium in US Magnesium's solar evaporation ponds and subsequently recovered during the magnesium refining process. US Magnesium has been stockpiling lithium from this process for many years. Their target capacity for lithium production is about 10,000 t of lithium carbonate per year and they are working towards that goal.

Exploration and Development

Significant exploration and development activities for industrial minerals in Utah have centered on lithium, fluorspar, halloysite, and potash resources (table 4). This summary generally excludes the activities of smaller aggregate or construction material operations, which are difficult to track but are often a significant part of industrial mineral exploration and development. The information for this section is largely from company websites, press releases, OGM records, and personal communications.

Lithium

As demand for lithium batteries continues to increase, Utah has remained a target for lithium exploration over the past several years, which has largely been focused on Utah's brine resources (Rupke and Boden, 2020). As previously noted, US Magnesium became Utah's first lithium producer in 2020,

Table 4. Select industrial mineral exploration and development projects in Utah, 2022.

Project	Commodity; Deposit	Location	County	Company	Progress
Compass Minerals Lithium	Lithium; GSL brine and interstitial brines of evaporation ponds	Great Salt Lake	Box Elder	Compass Minerals	Released updated in-place resource estimate in 2022 showing about 2.7 million tons LCE in GSL and interstitial brines
Halloysite Hills	Halloysite	North Tintic mining district (NE of Eureka)	Juab	Ionic Minerals Technologies	Drilled deposit in 2021 and 2022; defined a resource of 2.4 million tons of material at over 95% halloysite
Lithium Butte	Lithium, altered volcanics	Honeycomb Hills	Juab	Rockland Resources	Completed some initial sampling of lithium-enriched, altered volcanic rocks in 2022
Lost Sheep mine	Fluorspar; breccia pipes	Spor Mountain district	Juab	Ares Strategic Mining	Completed geophysical surveys in 2022; plans to begin production in 2023; continuing construction of processing facilities
Paradox Lithium	Lithium; brine	Paradox Basin	Grand	Anson Resources Ltd	Updated JORC resource estimate to 1.1 million tons of LCE; re-entered wells in 2022 to test brine and has plans to re-enter additional wells in 2023
Sage Plain Project	Potash; Paradox Fm. evaporites	Paradox Basin	San Juan	Sage Potash	Released an updated technical report that includes resource estimate of land holdings for potash in cycle 18 of the Paradox Fm.
Sevier Playa	Potash (SOP); shallow brine	Sevier Playa/Dry Lake	Millard	Peak Minerals	Received new funding in 2023 to pursue development

Note: GSL - Great Salt Lake; LCE - lithium carbonate equivalent; JORC - Joint Ore Reserves Committee

producing lithium carbonate as a byproduct of their magnesium refining process from Great Salt Lake brine. In mid-2021, Compass Minerals, another mineral producer on Great Salt Lake, announced the identification of a lithium resource with intent to develop production. Since then, Compass has prepared two technical reports describing their potential lithium resource. In the most recent, they reported an in-place indicated and inferred resource of 2.7 Mt of LCE within the interstitial brine of salts accumulated in their evaporation ponds and in the waters of Great Salt Lake (2.56 Mt) (Havasi, 2022). Compass' proposed production would rely on direct lithium extraction (DLE) technology, which is a developing technology that may allow economic extraction of lithium and overcomes problems with contaminants such as magnesium. Compass selected EnergySource Minerals as their DLE technology provider in late 2022. Compass intends to produce both lithium carbonate and lithium hydroxide by 2025 or 2026.

Anson Resources has been pursuing lithium resources in subsurface brines within a large block of claims (their Paradox Lithium project) near Moab in Grand County (figure 7). Since 2018, Anson has re-entered old oil and gas wells in the area to test brine flow rates and chemistry from the Paradox Formation and underlying Mississippian units. Analyses of brine from the tested wells have yielded lithium concentrations up to 253 ppm. In 2022, Anson re-entered two wells they had previously tested to confirm lithium concentrations in the Paradox Formation and to examine the deeper Mississippian units. From this work, Anson released an updated Australasian Joint Ore Reserves Committee (JORC)-compliant resource estimate that contains an indicated and inferred 1.1 Mt of LCE in brine (Anson Resources, 2022) within their land holdings that includes horizons in the Paradox Formation and underlying Mississippian carbonates. Average lithium concentrations of the horizons that make up the resource are estimated to range from 83 to 182 ppm. Anson is also evaluating coproduct/byproduct bromine, boron, and iodine and reported an indicated and inferred bromine resource of 5.8 Mt (Anson Resources, 2022). During 2022 and early 2023, Anson secured water rights for their project and expanded their land position to the west; they also acquired another land area south of the town of Green River. They intend to re-enter additional wells during 2023. Several other companies pursuing lithium in Utah brines hold land positions elsewhere in the Paradox Basin and in the Great Salt Lake Desert (e.g., the Bonneville Salt Flats, Pilot Valley). Because of the high magnesium content of Utah's brines, DLE technology would likely be needed to exploit lithium from any of Utah's brine deposits. Multiple DLE technologies are in development, but wide deployment of DLE technology has yet to be realized.

Apart from brines, Rockland Resources began evaluating some altered, lithium-bearing volcanic rocks in the Honeycomb Hills area of western Utah where a highly-evolved Pliocene rhyolite is exposed. Rockland holds claims in the area (called the "Lithium Butte property") and has done initial sampling of an altered tuff-breccia (figure 7). Channel samples

they collected during 2022 indicated an 83-ft-thick interval at 1388 ppm Li which contained a 26-ft section at 2155 ppm Li. They received permits to drill in the area in early 2023.

Fluorspar

Ares Strategic Mining has been working towards reopening the Lost Sheep fluorspar mine in the Spor Mountain district in Juab County (figure 7), and hopes to begin production in 2023. Historically, the Lost Sheep mine was the most productive fluorspar mine in Utah and has produced about 170,000 t of fluorspar from a series of mineralized breccia pipes. The mine has an active small mine permit from OGM. Since 2020, Ares has completed exploration drilling, geophysical surveys, and geologic mapping to delineate the fluorspar resources of their land holdings which consist of nearly 6000 acres of claims; their holdings span much of the Spor Mountain area and contain multiple potential mining areas. Work in 2022 included radiometric, magnetic, and gravity geophysical surveys of Spor Mountain. In 2021, Ares released an updated NI 43-101 technical report for the property (Puritch and others, 2021), but the report did not include a resource estimate. Construction of a fluorspar processing plant in Delta, Utah, is underway. Fluorspar is considered a critical mineral and the United States is almost completely import reliant for the mineral; consequently, if the Lost Sheep mine resumes production it would be the most significant fluorspar producer in the United States.

Halloysite

Recent interest in halloysite clay has focused on its unique nanotube microstructure for a broad range of applications in areas such as pharmaceuticals, fillers, catalysts, environmental remediation, and lithium-ion battery technology. Interest in halloysite nanotubes has increased in recent years, in part, because the cost of producing materials with synthetic nanotubes is substantially higher than extraction of naturally occurring nanotubes. About 4 miles north of the Dragon mine (a halloysite producer; see Clay and Shale section) and just west of Packard Peak in the North Tintic mining district, Ionic Mineral Technologies (IMT) is developing a halloysite deposit similar in nature to the Dragon mine. The deposit is called "Halloysite Hills" and in 2021 and 2022, IMT drilled 38 holes totaling 2490 feet of core (figure 7). Reportedly, several drill holes showed good halloysite from the surface to depth, including one hole to a depth of 177 feet. Their current halloysite resource estimate is 2.44 Mt of material at 95% halloysite. IMT intends to do more drilling in summer 2023 to expand their resource (Andre Zeitoun, written communication, April 2023).

Potash

In the early 2010s, due to high prices, several potash exploration projects were active across Utah, but by the late 2010s much of that interest had waned. However, in early 2022, significant increases in potash prices driven by the war in Ukraine

caused some of that interest to return. The project that was previously closest to development was a potassium sulfate project at Sevier Lake/Playa (figure 7). Crystal Peak Minerals had delineated a resource (Brebner and others, 2018) and received necessary permits and approvals for development, but was unable to raise sufficient capital to advance the project. Notably in 2023, Peak Minerals announced new monetary investment to develop the Sevier Lake/Playa potassium sulfate project. Another project (Sage Plain) with recent news is being developed by Sage Potash in the Paradox Basin in an area east of Monticello, Utah, on the Colorado border (figure 7). In early 2023, Sage Potash released an updated NI 43-101 that included an inferred potash resource of 176 Mt at 27% K_2O and 132 Mt at 23% K_2O in the upper and lower beds, respectively, of cycle 18 of the Paradox Formation (Thorson, 2023). Potash resource areas in Utah include the Paradox Basin, Great Salt Lake, the Bonneville Salt Flats, Sevier Lake, Blawn Mountain, and Pilot Valley (for additional details on Utah potash see Mills and Rupke, 2020, and Rupke, 2022).

URANIUM

The price of uranium has been increasing since early 2021 and in mid-2022 it hit the highest spot price seen since the Fukushima nuclear disaster in 2011. Several factors impacted uranium price in 2022, but the war in Ukraine had the most immediate short-term impact. Russia hosts a significant part of global uranium enrichment capacity, and the pivot away from Russian businesses by the United States and other nations resulted in a pinch point for uranium conversion and enrichment that drove spot prices in the first part of the year. Other influences supporting higher prices included continued buying of stockpile material by physical trusts and an overall positive attitude towards nuclear energy at the United Nations' COP27 conference, though nuclear energy was excluded from formal discussion. Factors that pushed prices lower were economic concerns around recession and inflation. Most analysts remain bullish on uranium, particularly given the revival of utility companies locking in long-term supply contracts and generally positive fundamentals for nuclear energy in a carbon neutral economy.

Production

No uranium was mined in Utah in 2022. Active uranium mining in the state has been suspended since 2012, despite several established uranium resources and existing mining permits (Mills and Jordan, 2021). Utah is home to the White Mesa Mill, which is the only active conventional uranium mill in the United States. White Mesa is owned by Energy Fuels and produced 162,000 lb U_3O_8 in 2022 from feedstocks that were not produced in Utah. Energy Fuels also secured long-term supply contracts with U.S. nuclear utilities and an additional supply contract for the newly established

U.S. Uranium Reserve. Energy Fuels has recently shifted the focus of the White Mesa mill to REE refinement and in 2022 produced approximately 226 t of rare earth carbonate. Like uranium, the feedstock for the REE production was imported into Utah. The company also reported that they sold 642,000 lbs of stockpiled vanadium during 2022 and is preparing four uranium (-vanadium) mines (La Sal, Beaver, and Whirlwind mines in Utah; Pinyon Plain mine in Arizona) for resumption of mining. The preparations include both surface and underground rehabilitation.

Anfield Energy, owner of the idled Shootaring Canyon uranium mill in Garfield County, announced in 2022 it was commissioning a reactivation plan to bring the mill back online. The company plans to revive the existing uranium circuit and include a new vanadium recovery circuit. Anfield also owns the nearby Frank M mine which has an indicated and inferred resource of 2.3 Mlb U_3O_8 based on a 2008 NI 43-101 technical report (Mills and Jordan, 2021). If the Shootaring Canyon mill returns to functionality, Utah would host the only two active conventional uranium mills in the United States.

Exploration and Development

Exploration activity for uranium in Utah increased notably in 2022, reflecting the underlying optimism for prolonged strength in the uranium market. As in previous years, most of this activity was related to companies acquiring projects or land positions; however, an increasing number of companies are executing systematic exploration programs. Notable uranium exploration projects in 2022 are discussed below and located on figure 7, with further projects summarized in table 3.

- East Canyon project, San Juan County (Dry Valley district): Uvre Ltd. acquired the East Canyon project containing the historical underground Nonesuch and Bonanza mines in early 2022. Following encouraging channel sampling with results up to 1.3% U_3O_8 and 4.5% V_2O_5 , Uvre initiated a mixed RC and diamond core drilling program of 11 holes over Nonesuch and 5 holes over the Bonanza prospect. Assays from the drill program delineate multiple zones of uranium-vanadium mineralization at less than 200 ft from surface, although intercepts are typically short. Drilling highlights included 7 ft at 0.12% U_3O_8 and 5 ft at 1.0% V_2O_5 in different intervals in hole ECDD18 at the Bonanza prospect.
- Southeast Utah project (including Tony M, Daneros, and Rim mines), Garfield and San Juan Counties (South Henry Mountains, Red Canyon, Dry Valley districts): Consolidated Uranium Inc. secured a portfolio of uranium (-vanadium) projects in Utah in 2021, and in 2022 continued exploration programs at three of the assets. At the Tony M mine in the South

Henry Mountains mining district in Garfield County, drilling was completed on an eight-hole, 6000-ft RC and core program which led to publication of an updated indicated and inferred mineral resource containing 8.8 Mlb U_3O_8 equivalent. At the Daneros mine in the Red Canyon mining district in San Juan County, drilling commenced on a planned eight-hole, 7200-ft RC and core program. The program was designed to test for extensions of the historical resource. At the Rim mine in the Dry Valley mining district in San Juan county, drilling commenced on a planned 15-hole, 10,000-ft RC and core program. The program was designed to test modeled continuations and extensions of the historical resource. Results and assays from these programs are pending and will inform the 2023 exploration program.

COAL

Production and Distribution

Five Utah coal operators produced 10.7 Mt of coal valued at \$504 million from five underground mines and one surface mine in 2022, the lowest production total since 1978 (figures 10, 11, and 12; table 5). Production in 2022 decreased by 15% compared with 2021, mostly due to reduced production at Wolverine Fuels' Skyline mine related to difficult mining conditions, and significant production declines at Lila Canyon as the facility endured a lengthy closure (September 2022 to January 2023) resulting from a "thermal event." Minor production declines were also reported for the Emery and Coal Hollow mines. In contrast, the Sufco and Gentry mines both increased production slightly. After several years of decline, employment at active or recently active mines has stabilized in the 1300 employee range, averaging 1361 employees in 2022—a 15% increase from a low of 1185 employees in 2016—and slightly higher than the 1336 employees logged in 2021 (figure 10). Employment is expected to decrease slightly in 2023 due to employment uncertainty at the Lila Canyon mine. Coal mining productivity, the amount of coal produced in tons per employee hour, peaked in 2002 at 8.0 tons/employee hour, but has averaged only about 4.6 tons/employee hour during the past four years (figure 10). Productivity dropped to 3.8 tons/employee hour in 2022 mostly due to the temporary closure at the Lila Canyon mine.

Demand at Utah coal-fired power plants was fairly stable from 2000 to 2015 at about 15.2 Mt a year, but dropped to an average of 11.6 Mt between 2016 and 2021, including a dip in 2020 to 10.5 Mt due to the COVID-19 pandemic (figure 13). Utah power plant consumption dropped significantly again in 2022, to 10.2 Mt, as the Intermountain Power Plant started to ramp down operation and less coal was used at Hunter and Huntington as these plants flex power output based on availability of new solar energy resources.

Although fuel switching or closure at other U.S. coal-fired power plants has reduced domestic demand for Utah coal, Utah operators have taken advantage of a stronger foreign export market, sending an estimated 1.9 Mt of coal overseas to Asia in 2022 (figure 13).

During our annual coal mine visits in spring 2023, all mine operators reported strong demand for Utah coal, both domestically (the closure of Lila Canyon created localized shortages) and internationally, but meeting this new surge in demand has been challenging. With demand outpacing supply, coal prices increased substantially, with western U.S. spot prices above \$40 per ton in fall 2022 and international spot market prices exceeding \$400 per ton in fall 2022 (prices from EIA and ICE Newcastle; spring 2023 spot prices are back to about \$35 per ton in the western U.S. and \$165 per ton internationally). Labor shortages were cited as the number one issue holding back production; in fact, one operator indicated that there were currently over 200 open coal mining jobs in Utah. The defunding of the coal industry has also affected the ability for operators to finance new mine equipment and improvements, and coupled with continued difficult mining conditions and a burdensome regulatory environment, the Utah coal industry will continue to struggle to maintain current activities. Despite the current high prices and strong demand, with operations at Lila Canyon limited until fall 2023 and continued difficult mining at other operations, Utah's total coal production is expected to decrease to about 9.8 Mt in 2023.

For the first time in the history of Utah's coal industry (except for maybe the very early days), after the idling of the Dugout Canyon mine in 2019, coal is no longer produced in Carbon County (figure 10). In contrast, Sanpete County hosted significant coal production for the first time starting in 2017 when operations at the Skyline mine moved to the southwestern Flat Canyon area. Coal production in 2022 came from Emery (4.7 Mt, 44%), Sevier (3.9 Mt, 36%), Sanpete (1.8 Mt, 16%), and Kane (354,000 t, 3.3%) Counties.

In 2022, the majority of Utah coal, 7.0 Mt, was produced from the Wasatch Plateau coalfield; 2.3 Mt came from one mine (Lila) in the Book Cliffs coalfield, 1.1 Mt from the Emery mine in the Emery coalfield, and 0.4 Mt from the Coal Hollow mine in the Alton coalfield (table 5). In addition, nearly all Utah coal production in 2022, 88% (9.5 Mt), was produced from federal land, whereas only 390,000 t (3.6%) was from state-owned land (figure 10). Federal coal production has dominated in Utah since 2012, when the now-closed Deer Creek mine's state-owned Mill Fork coal tract reverted back to federal ownership after a 22 Mt 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 2022 coal production came from private lands (8.0%, 861,000 t) at the Gentry, Emery, and Coal Hollow mines.

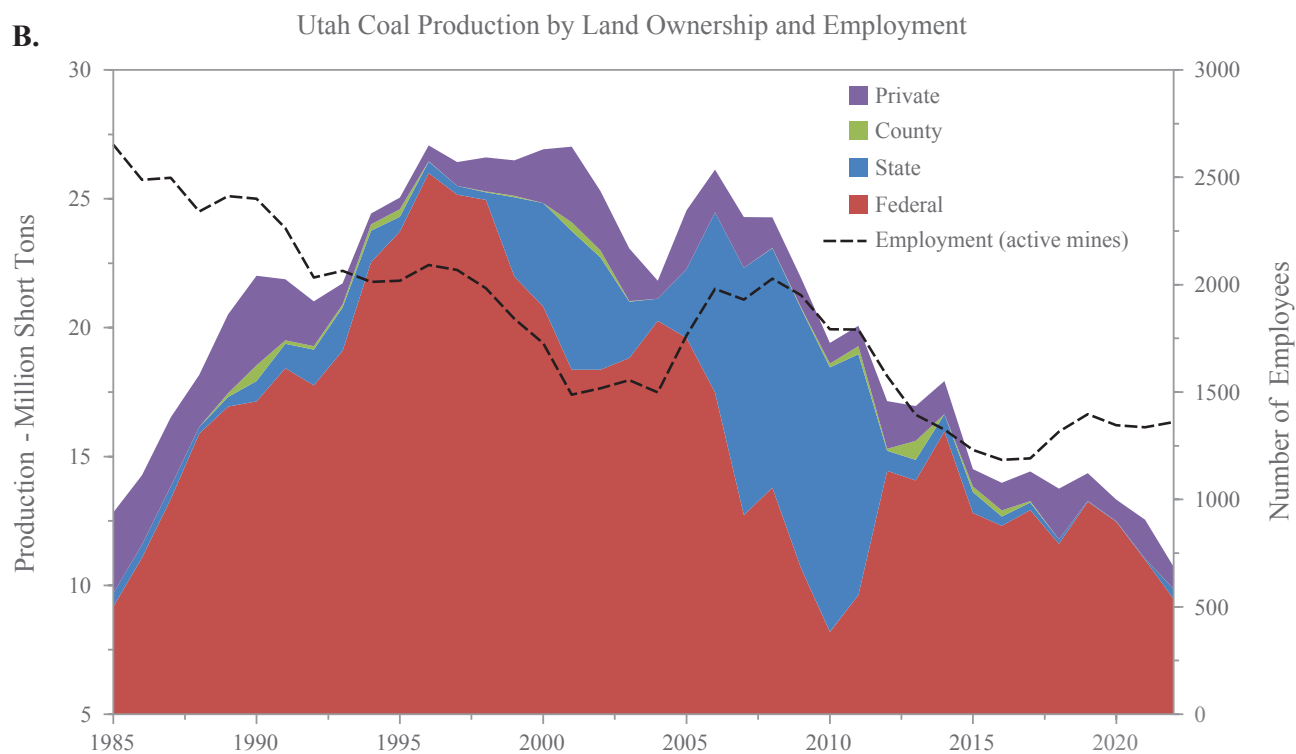
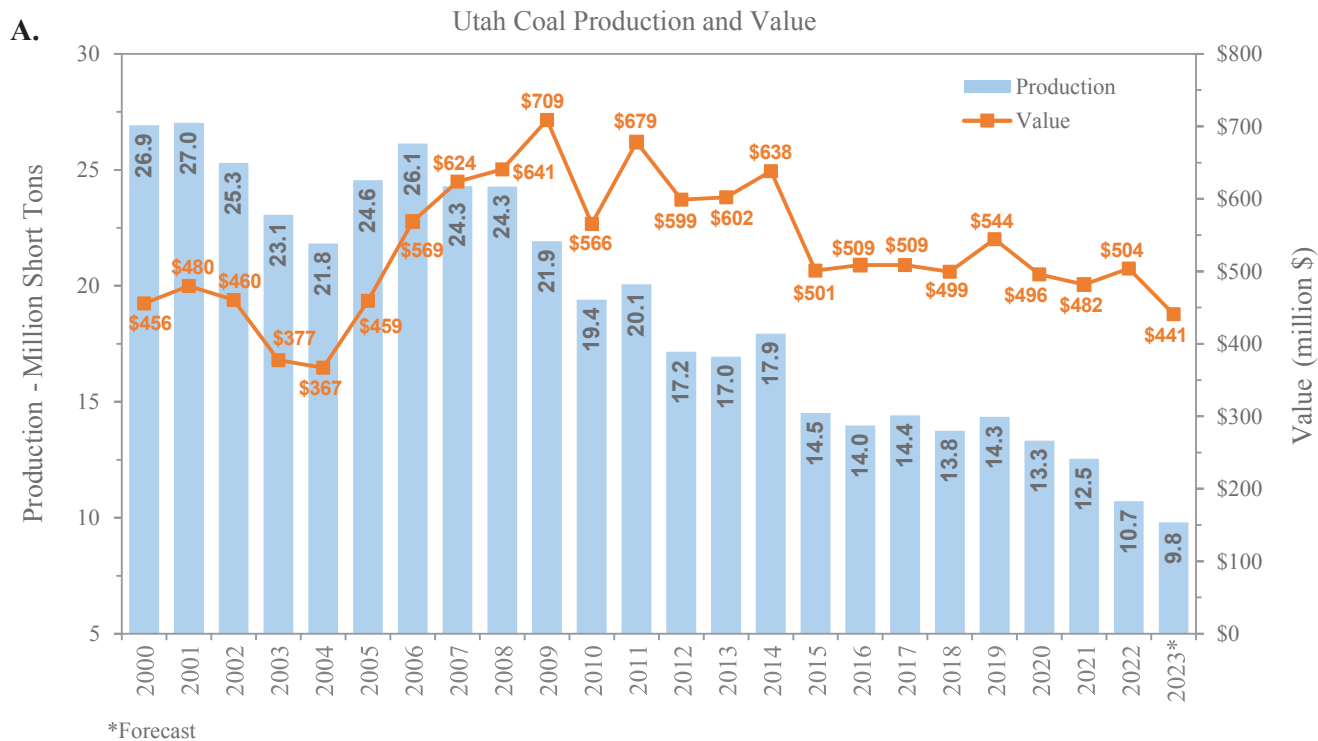


Figure 10. (A) Utah coal production and value in nominal dollars, 2000–2023. Data source: Utah Geological Survey and U.S. Energy Information Administration. **(B)** Utah coal production by land ownership and employment at active mines, 1985–2022. Data source: Utah Geological Survey and Mine Safety and Health Administration.

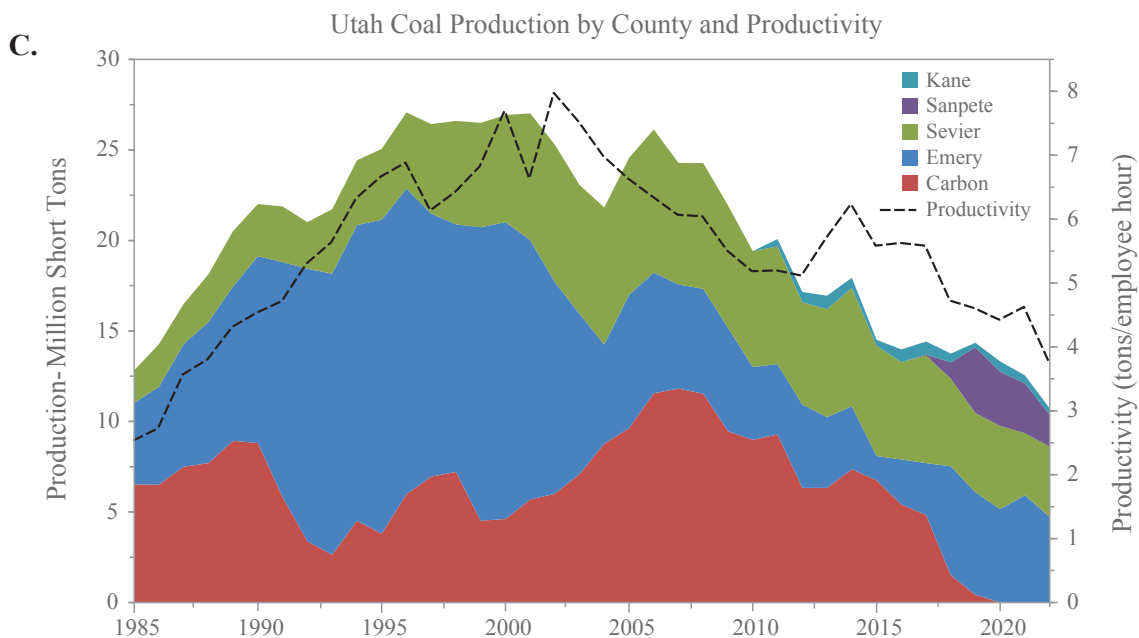


Figure 10. Continued (C) Utah coal production by county and coal mining productivity, 1985–2022. Data source: Utah Geological Survey and Mines Safety and Health Administration.

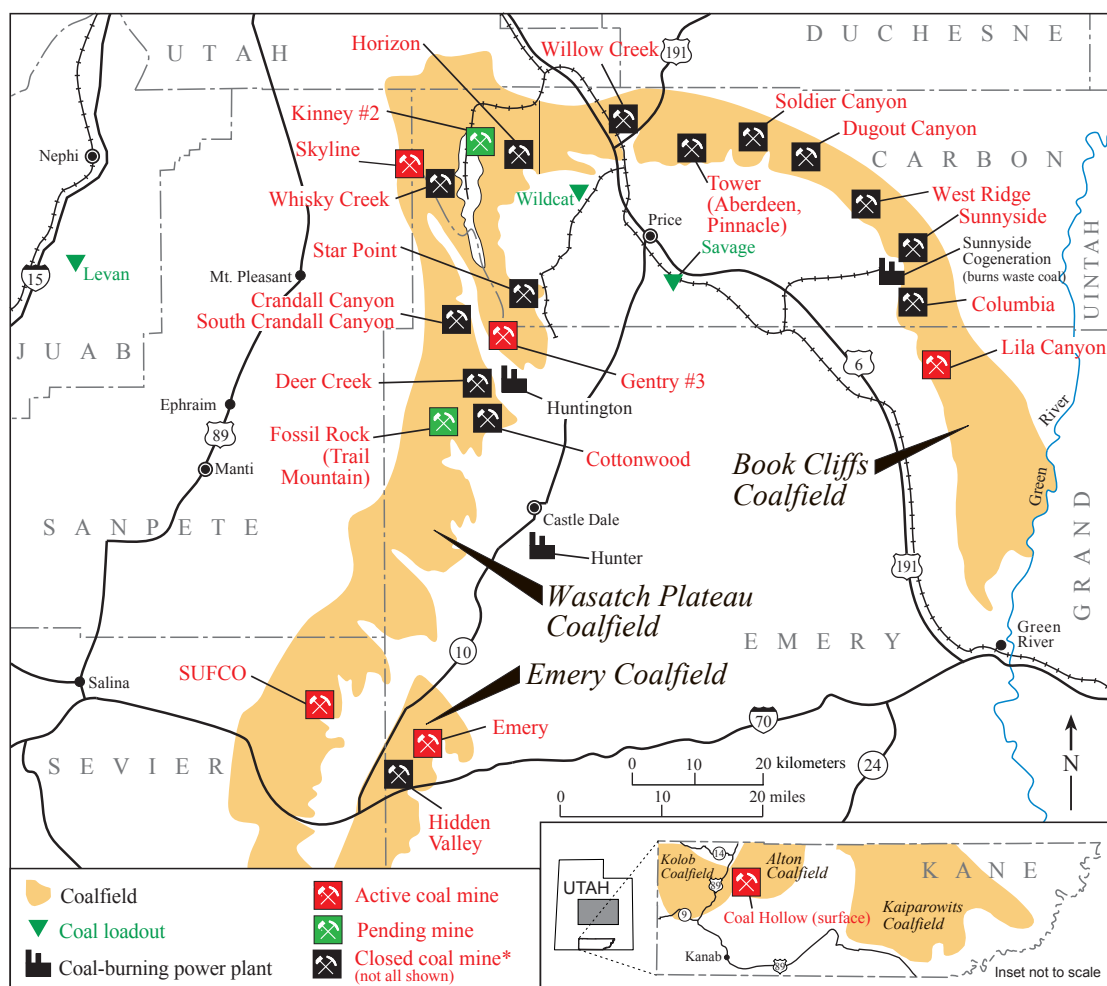


Figure 11. Location and status (at time of publication) of Utah coal mines and associated facilities.

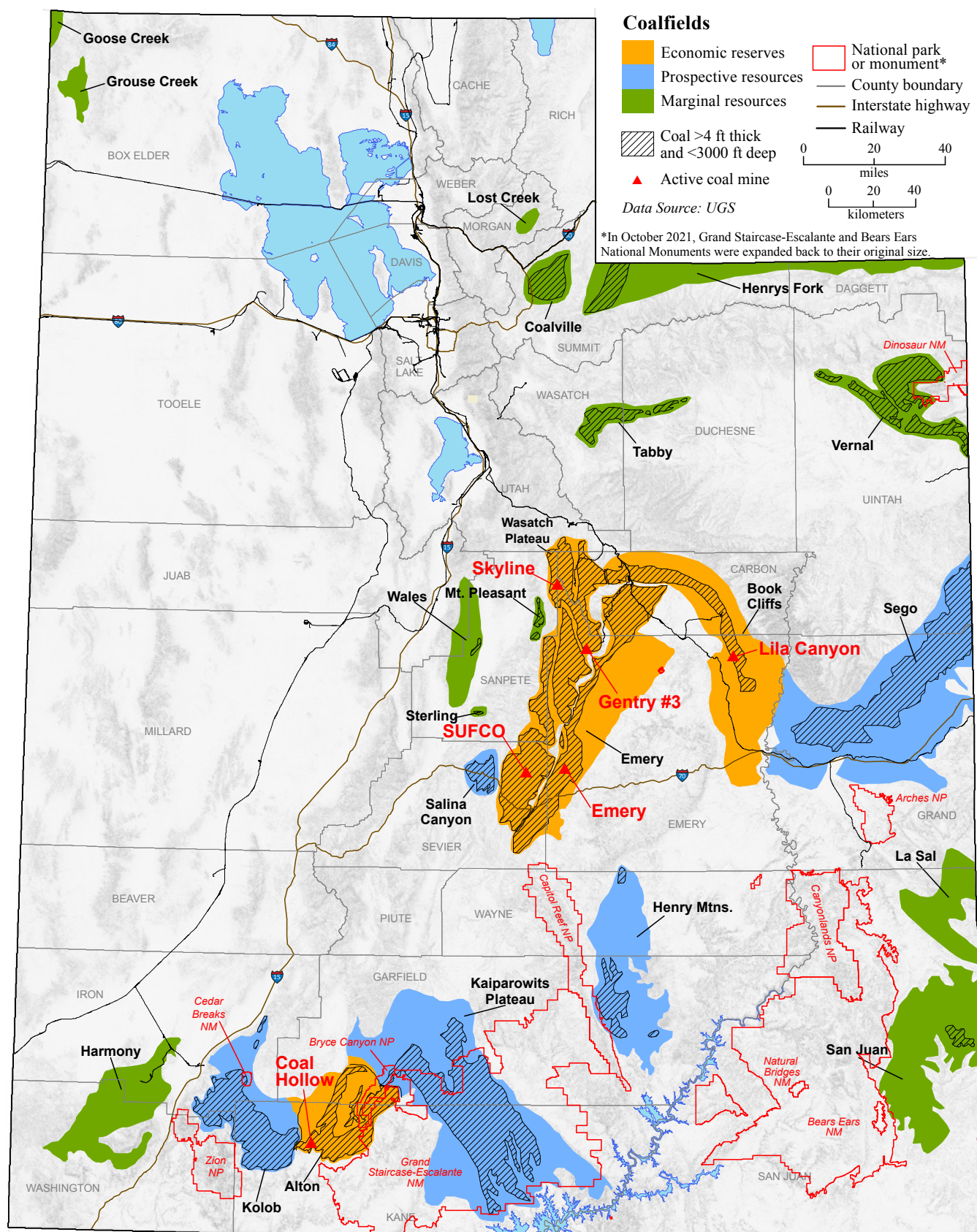


Figure 12. Location of active Utah coal mines and coalfields.

Table 5. Coal production in Utah by coal mine, 2010–2023.

Company	Mine ¹	County	Coalfield	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023*
thousand short tons																	
Canyon Fuel Company, LLC - Wolverine Fuels, LLC ²	Dugout Canyon	Carbon	Book Cliffs	2307	2395	1588	561	676	763	650	626	557	430	--	--	--	--
	Skyline #3	Carbon/ Sanpete/ Emery ³	Wasatch Plateau	3050	2950	1954	3135	4170	4409	4767	4389	3614	3896	3713	3530	2521	3500
	SUFCO	Sevier	Wasatch Plateau	6398	6498	5651	5959	6539	6095	5375	5947	4842	4374	4601	3425	3882	3300
Fossil Rock Resources, LLC - Wolverine Fuels LLC ⁴	Fossil Rock (Trail Mtn.)	Emery	Wasatch Plateau	--	--	--	--	--	--	--	--	--	--	--	--	--	100
Bronco Utah Operations, LLC ⁵	Emery	Emery	Emery	999	--	--	4	--	--	--	135	442	694	474	1171	1063	1300
Gentry Mountain Mining, LLC - COP Coal Development Co. ⁶	Gentry #3	Emery	Wasatch Plateau	--	--	--	--	--	218	170	205	102	562	660	511	600	750
	Gentry #4	Emery	Wasatch Plateau	--	592	1004	875	1061	757	724	754	893	488	11	--	--	--
East Mountain Energy - PacifiCorp	Deer Creek	Emery	Wasatch Plateau	2954	3143	3295	2785	2083	15	--	--	--	--	--	--	--	--
Hidden Splendor Resources, Inc. - America West Resources, Inc.	Horizon	Carbon	Wasatch Plateau	270	370	210	--	--	--	--	--	--	--	--	--	--	--
Utah Land Resources, Inc. - ACNR Holdings, Inc. ⁷	West Ridge	Carbon	Book Cliffs	3355	3566	2579	2629	2514	1580	--	--	--	--	--	--	--	--
Emery County Coal Resources - ACNR Holdings, Inc. ⁷	Lila Canyon	Emery	Book Cliffs	72	157	304	257	335	350	1587	1638	2816	3664	3296	3471	2299	500
Alton Coal Development, LLC	Coal Hollow	Kane	Alton	--	403	570	747	555	316	671	724	488	240	569	434	354	350
	Burton #1	Kane	Alton	--	--	--	--	--	11	34	--	--	--	--	--	--	--
Total				19,405	20,074	17,155	16,953	17,933	14,513	13,978	14,417	13,753	14,347	13,325	12,542	10,719	9800

Source: UGS coal company questionnaire

*Forecast

¹All mines are underground except Coal Hollow, which is a surface mine.²Bowie Resources bought Canyon Fuel from Arch Coal in summer 2013. In late 2018, Bowie changed their name to Wolverine Fuels.³2022 production by county: Sanpete = 1,758,956 tons; Emery = 762,244 tons. 2021 production by county: Sanpete = 2,750,773 tons; Emery = 778,989 tons. 2020 production by county: Sanpete = 3,000,319 tons; Emery = 712,681 tons. 2019 production by county: Sanpete = 3,645,133 tons; Emery = 250,695 tons. 2018 production by county: Sanpete = 906,716 tons; Emery = 1,765,410 tons; Carbon = 941,447 tons. 2017 production by county: Sanpete = 43,949 tons; Emery = 136,203 tons; Carbon = 4,208,538 tons. 2010-2016: all production in Carbon County.⁴Wolverine is working to reopen the closed Trail Mountain mine (last production was 2001), first CM mining is expected in late 2023.⁵Bronco bought the Emery mine from CONSOL Energy in 2015.⁶COP bought the Castle Valley mines when Rhino went into bankruptcy in late 2020, mines were renamed Gentry. In summer 2010, Rhino bought the Castle Valley mines from C.W. Mining (Co-op); mines were formerly called Bear Canyon.⁷ACNR Holdings, Inc. was previously Murray Energy.

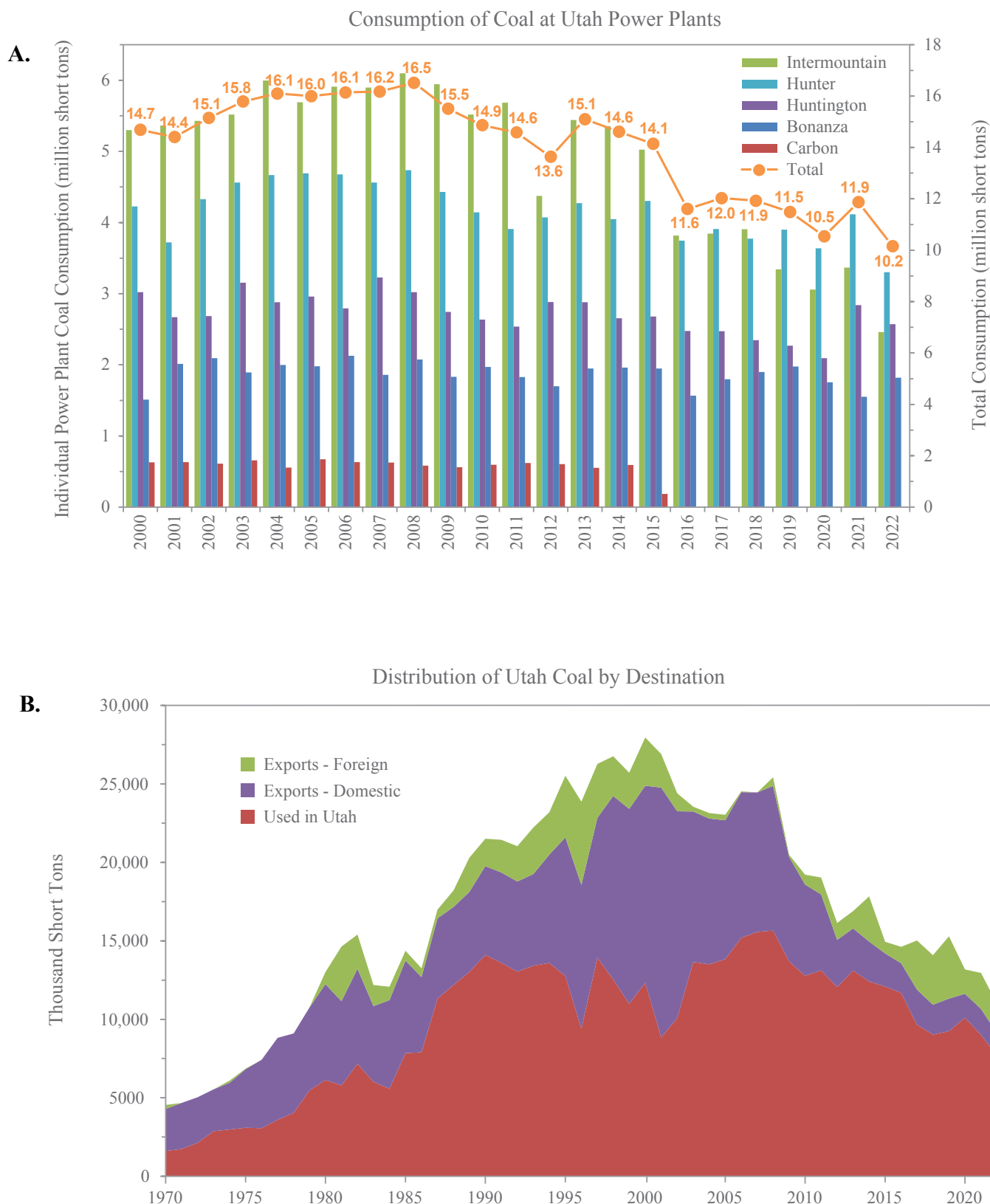


Figure 13. (A) Consumption of coal at Utah power plants, 2000–2022. Data source: U.S. Energy Information Administration. Notes: (1) A generator at the Intermountain Power Plant was offline for several months in 2012, resulting in decreased coal consumption. (2) The Bonanza power plant in Uintah County gets its coal from the Deserado mine just over the border in Colorado. (3) The Carbon plant, Carbon County, shut down in spring 2015. (4) The Sunnyside plant in Carbon County is not included since it burns waste coal. **(B)** Distribution of Utah coal by final destination, 1970–2022. Data source: Utah Geological Survey and U.S. Energy Information Administration.

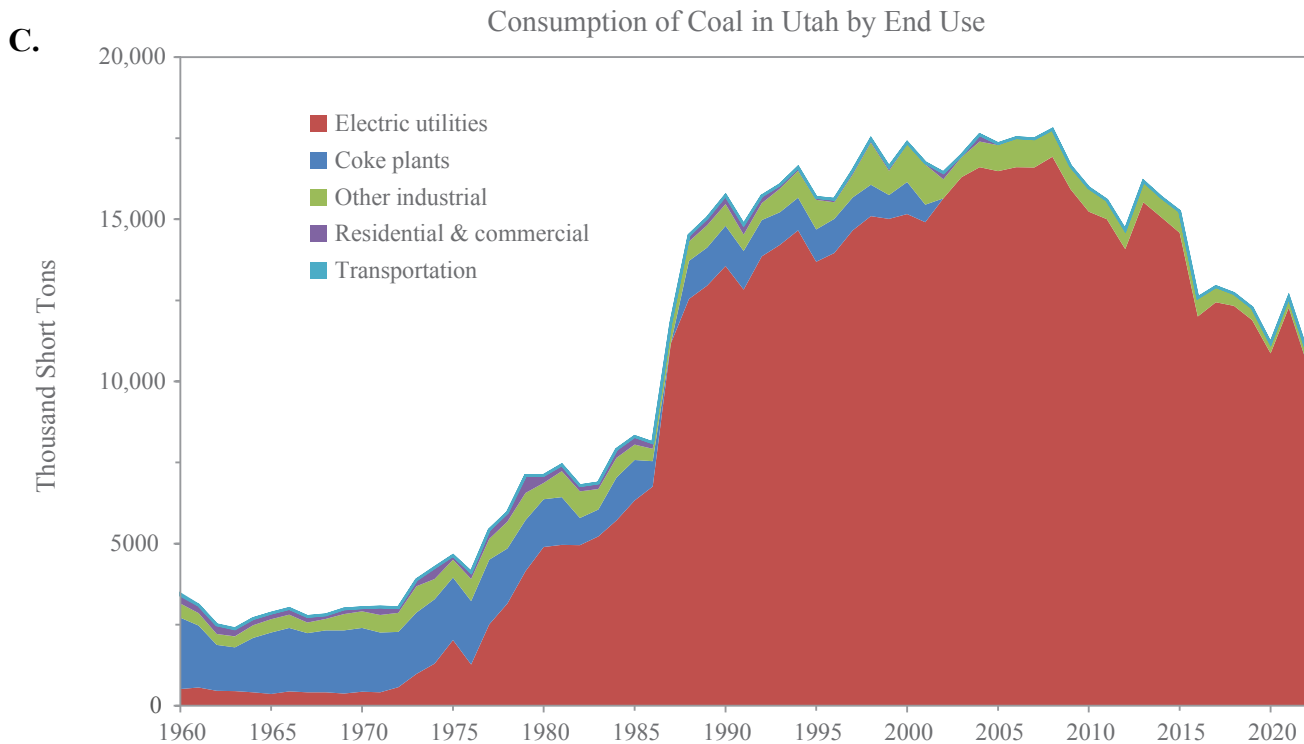


Figure 13. Continued. **(C)** Consumption of coal in Utah by end use, 1960–2022. Data source: U.S. Energy Information Administration. Notes: Electric utilities includes waste coal burned at Sunnyside.

The Lila Canyon and Emery mines will both see changes to surrounding land ownership when the John D. Dingell, Jr. Conservation, Management, and Recreation Act is finalized. Significant coal resource tracts near both mines will convert from federal ownership to state (SITLA) ownership, facilitating a more streamlined permitting process for future mining.

The total amount of Utah coal distributed to the U.S. market in 2022 was 9.1 Mt, over 1.5 Mt less than 2021 (figure 13). As recently as 2008, Utah operators distributed 25 Mt of coal; over 9.2 Mt was exported to other states and 16 Mt was used in-state. In 2022, only 1.4 Mt of Utah coal was shipped to other states, whereas 7.8 Mt was used locally. The vast majority of Utah coal, about 85% (7.8 Mt), went to the electric utility market, mainly within the state. Utah coal deliveries to the industrial sector totaled 1.4 Mt in 2022, which is significantly less than peak deliveries of 4.4 Mt in 2003. Data are similar for consumption of coal in Utah, with 10.6 Mt consumed at Utah power plants in 2022 (this includes about 400,000 t of waste coal burned at the Sunnyside power plant) and about 350,000 t used at industrial facilities, the latter being significantly lower than in the 1990s to mid-2010s (figure 13).

The demand for Utah coal has sharply decreased over the past several years as coal-fired power plants have closed or switched to natural-gas-fired generation. Nationally, operators plan to retire 8.9 gigawatts of coal-fired power plant capacity

in 2023 alone (U.S. EIA, 2023b). 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 emission-reducing technology. This removed about 600,000 t of coal from the Utah market. Between 2016 and 2022, consumption of coal at Utah's remaining coal-fired power plants averaged 11.4 Mt, a 26% drop from pre-2016 consumption (figure 13). Most of this reduction occurred at the Intermountain Power Plant (IPP) near the town of Delta (a reduction of about 1.7 Mt) as the City of Los Angeles, the majority owner, has purchased less electricity from the plant due to favoring mostly renewable energy sources. This drop in electricity generation seems to be accelerating as IPP only burned 2.5 Mt of coal in 2022 compared to the recent average of about 3.6 Mt. 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, at which time a new plant, currently under construction, will burn a combination of natural gas and "green/blue" hydrogen. In addition, starting in 2016, 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 lower their output during these peak solar times, thus consuming less coal (on average about 300,000 t less per year at both Hunter and Huntington). Furthermore, Rocky Mountain Power has announced that it will close the Hunter and Huntington power plants by 2032,

but also plans to reduce operations between now and then. All these plant closures, which will ultimately remove about 10 Mt of coal demand, will have a profound impact on Utah coal mining operations in the next five to ten years.

Foreign exports of Utah coal averaged 2.9 Mt per year in the 1990s, peaking at 5.3 Mt in 1996 (figure 13). 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 Mt in 2014, before dropping again in 2015 to only about 0.7 Mt and 1.0 Mt in 2016. However, a recently expanding foreign export market has provided new opportunities for Utah coal operators. With diminished port capacity on the West Coast of the United States, Utah operators have sought out alternate port facilities (e.g., Gulf of Mexico) to send their coal overseas. Utah operators have exported between 1.6 and 4.0 Mt per year for the past five years and shipped about 1.9 Mt of coal in 2022.

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

Exploration/Development Updates for 2022/2023

- Lila Canyon mine: Production halted in September 2022 when a “thermal event” was detected in a mined-out area of the underground workings. After extensive work to extinguish the fire, miners re-entered the mine in early 2023 and have been constructing new segments of main tunnels, which will result in small amounts of continuous miner produced coal. Resumption of longwall mining depends on several factors (e.g., equipment condition, etc.), but operators hope that longwall mining can resume in late 2023. Total coal production at Lila Canyon in 2023 is projected to be about 500,000 t, with a possible return to full production (about 3 Mt) in 2024.
- Gentry mine: COP Coal Development, LLC bought the Castle Valley mines when Rhino Resources went into bankruptcy in late 2020—the mines were renamed Gentry. Gentry mine #4 was closed in early 2020 and all mining now takes place in the Gentry #3 mine from the Bear, Blind, and Hiawatha coal beds. Total production for 2023 should be about 750,000 t.
- Emery mine: Production at the Emery mine more than doubled in 2021 as four continuous miner machines were brought online and this level of production continued into 2022 (about 1.1 Mt). Emery is waiting for the finalization of the Dingell Act before leasing/permitting new coal reserves that will soon be under SITLA jurisdiction.
- Sufco mine: Longwall development shifted to the federal Greens Hollow tract while production finishes in the federal Pines district to the northeast (finished in spring 2023). Longwall production in Greens Hollow should start in June 2023 with total production for the year estimated at about 3.3 Mt.
- Skyline mine: Operations at the Skyline mine shifted to the Lower O'Connor B seam in the Flat Canyon area in 2017. Complicated geology was the cause for lower production in 2022, down about 1 Mt from 2021, but operators expect to be back to about 3.5 Mt in 2023.
- Fossil Rock/Trail Mountain/Cottonwood Tract: Owned by Fossil Rock Resources, LLC, a subsidiary of Wolverine Fuels, this SITLA coal tract contains nearly 50 Mt of mineable coal in the Hiawatha seam. Wolverine recently re-entered the closed Trail Mountain mine to evaluate access to the adjacent Cottonwood reserves, with possible continuous miner development starting as early as fall 2023.
- Coal Hollow mine: Alton Coal Development has completed mining on the northern private lease and has moved back to areas in the south which are private surface, but federal coal. They are waiting for final approval of their new permit before moving forward with continued surface mining on federal land. Plans include some auger and highwall development to maximize efficiency.

UNCONVENTIONAL FUELS

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 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 up to 80 gallons of oil per ton of rock. The Mahogany zone is 70 to 120 ft thick and is accessible via extensive outcrops along the eastern and southern flanks of the basin.

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 three companies have interests in Utah's oil shale resources: Enfit American Oil, Red Leaf Resources, and TomCo Energy. These companies all hold land in the southeastern Uinta Basin but have reported limited exploration activity in recent years related to oil shale development.

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 deposits, though small compared to Canadian resources, contain the largest resource in the United States. The deposits hold roughly 23 to 29 billion bbls of in-place bitumen. The Uinta Basin of northeast Utah has 25 oil sand deposits containing an estimated 9 to 11 billion bbls. Twenty-two oil sand deposits containing another roughly estimated 14 to 18 billion bbls are in the central-southeast part of the state, and six minor deposits containing negligible oil occur in other parts of the state (Ritzma, 1979). Similar to oil shale, conventional mining methods would likely be used to mine the oil sand for further processing. Given the relative ease of recent oil production from tight oil reservoirs, less incentive exists to improve bitumen extraction and refining techniques to efficiently and sustainably develop Utah's oil sand. 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 deposits.

Despite these challenges and competition from traditional drilling, a few companies continue to pursue development of Utah's oil sand deposits. One Utah oil sand deposit that consistently generates interest is Asphalt Ridge because of its proximity to Vernal, Utah. Companies with land holdings or recent activities on Asphalt Ridge include Tar Sands Holdings II, TomCo Energy, and Vivakor. TomCo released results from an independent reserve report and completed a three-hole drilling program in an area of Asphalt Ridge in 2022.

ACKNOWLEDGMENTS

This report was compiled from a wide assortment of published and unpublished sources. In addition, we particularly appreciate the cooperation and assistance of Alton Coal Development, Bronco Utah Operations, Utah Division of Oil, Gas and Mining (Kim Coburn), COP Coal Development, SITLA (Andy Bedingfield), ACNR Holdings, Wolverine Fuels, and all the companies that responded to the 2022 UGS production and exploration surveys. We also thank Jocelyn Gerst and Thomas Newman at Holcim for allowing us to use a photo of the Devil's Slide quarry for the cover of this year's annual report.

REFERENCES

Anson Resources, 2022, Anson delivers 1Mt LCE mineral resource at Paradox Lithium project: Online, <https://wcsecure.weblink.com.au/pdf/ASN/02592902.pdf>, accessed May 2023.

Boden, T., and Tripp, B.T., 2012, Gilsonite veins of the Uinta Basin, Utah: Utah Geological Survey Special Study 141, 50 p., 1 plate, <https://doi.org/10.34191/SS-141>.

Brebner, J., Lefavre, A., Bairos, D., Laxer, C., Henchel, L.D., Reinke, R., and Ennis, S., 2018, NI 43-101 technical report summarizing the feasibility study for the Sevier Playa potash project, Millard County, Utah: unpublished Canadian National Instrument (NI) 43-101 technical report prepared for Crystal Peak Minerals Inc., 338 p.

Dyer, T.L., Tietz, P.G., and Austin, J.B., 2014, Technical report on the West Desert Zinc-Copper-Indium-Magnetite Project, preliminary economic assessment, Juab County, Utah: unpublished Canadian National Instrument (NI) 43-101 technical report prepared for InZinc Mining Ltd., 210 p.

Fortier, S.M., Nassar, N.T., Lederer, G.W., Brainard, J., Gambogi, J., and McCullough, E.A., 2018, Draft critical mineral list—Summary of methodology and background information—U.S. Geological Survey technical input document in response to Secretarial Order No. 3359: U.S. Geological Survey Open-File Report 2018-1021, 26 p.

Havasi, J., 2022, Technical report summary, updated initial assessment, lithium and LCE mineral resource estimate, Compass Minerals International, Inc., GSL/Ogden site, Ogden, Utah, USA: unpublished technical report prepared for Compass Minerals, 188 p.

Kerr, S.B., Todd, J.N., and Malhotra, D., 2017, The Blawn Mountain project updated prefeasibility report, revised, Beaver County, Utah: unpublished Canadian National Instrument (NI) 43-101 technical report prepared for Potash Ridge Corporation, variously paginated.

Krahulec, K., 2018, Utah mining districts: Utah Geological Survey Open-File Report 695, 196 p., 1 plate, <https://doi.org/10.34191/OFR-695>.

Materion, 2023, 2022 Annual Report: Online, <https://investor.materion.com/financials/annual-reports-and-proxies/default.aspx>, accessed May 2023.

Mejia, J., and Aliakbari, E., 2023, Fraser Institute annual survey of mining companies, 2022: Online, <https://www.fraserinstitute.org/sites/default/files/annual-survey-of-mining-companies-2022.pdf>, accessed May 2023.

Mills, S.E., and Jordan, B., 2021, Uranium and vanadium resources of Utah—an update in the era of critical minerals and carbon neutrality: Utah Geological Survey Open-File Report 735, 26 p., 1 appendix, <https://doi.org/10.34191/OFR-735>.

Mills, S.E., and Rupke, A., 2020, Critical minerals of Utah: Utah Geological Survey Circular 129, 49 p., <https://doi.org/10.34191/C-129>.

- Mills, S.E., and Rupke, A., 2023, Critical minerals of Utah, second edition: Utah Geological Survey Circular 135, 47 p., <https://doi.org/10.34191/C-135>.
- Puritch, E., Sutcliffe, R.H., Brown, F.H., Salari, D.J., and Czarnowsky, A., 2021, Technical report on the Lost Sheep fluorspar property, Juab County, Utah, U.S.A.: unpublished Canadian National Instrument (NI) 43-101 technical report prepared for Ares Strategic Mining Inc. by P&E Mining Consultants Inc., 164 p.
- Rio Tinto, 2023, Annual report 2022: Online, <https://www.riotinto.com/en/invest/reports/annual-report>, accessed May 2023.
- Ritzma, H.R., 1979, Oil-impregnated rock deposits of Utah: Utah Geological and Mineral Survey Map 47, scale 1:750,000, <https://doi.org/10.34191/M-47>.
- Rupke, A., 2022, Potash resources of Utah—an annotated bibliography: Utah Geological Survey Open-File Report 746, 14 p., <https://doi.org/10.34191/OFR-746>.
- Rupke, A., and Boden, T., 2013, Gypsum resources of the San Rafael Swell, *in* Morris, T.H., and Ressetar, R., editors, The San Rafael Swell and Henry Mountains Basin—Geologic Centerpiece of Utah: Utah Geological Association Publication 42, p. 445–460.
- Rupke, A. and Boden, T., 2020, Lithium brine analytical database of Utah: Utah Geological Survey Open-File Report 730, 2 p., <https://doi.org/10.34191/OFR-730>.
- S&P Global Market Intelligence, 2023, World exploration trends 2023: Online, <https://pages.marketintelligence.spglobal.com/world-exploration-trends-2023-report-EMC.html>, accessed May 2023.
- Stantec, 2023, Mineral resource estimate statement, Revision 0, American West Metals Limited West Desert zinc, copper, and silver project, JORC-compliant mineral resource estimate: unpublished JORC-compliant mineral resource estimate prepared for American West Metals Limited, 4 p.
- Thorson, J.P., 2023, NI 43-101 technical report for the Sage Plain potash property: unpublished Canadian National Instrument (NI) 43-101 technical report prepared for Sage Potash Corporation, 88 p.
- Tripp, G.T., 2002, Production of magnesium from the Great Salt Lake, *in* Gwynn, J.W., editor, Great Salt Lake—An overview of change: Utah Geological Survey Special Publication, p. 221–225, <https://doi.org/10.34191/GSL2002>.
- U.S. Energy Information Administration, 2023a, Quarterly coal report: Online, <https://www.eia.gov/coal/production/quarterly/>, accessed April 2023.
- U.S. Energy Information Administration, 2023b, Coal and natural gas plants will account for 98% of U.S. capacity retirements in 2023: Online, <https://www.eia.gov/today-inenergy/detail.php?id=55439>, accessed May 2023.
- U.S. Geological Survey, 2022, 2022 Final list of critical minerals: Federal Register Notice 87 FR 10381, p. 10381–10382, document number 2022-04027.
- U.S. Geological Survey, 2023a, Mineral commodity summaries 2023: Online, <https://pubs.usgs.gov/periodicals/mcs2023/mcs2023.pdf>, accessed May 2023.
- U.S. Geological Survey, 2023b, Crushed stone and sand and gravel in the fourth quarter 2022: Online, <https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/mis-2022q4-conag.pdf>, accessed May 2023.
- U.S. Geological Survey Oil Shale Assessment Team, 2011, Oil shale resources in the Eocene Green River Formation, greater Green River Basin, Wyoming, Colorado, and Utah: U.S. Geological Survey Data Series 69-DD, no pagination.
- Vanden Berg, M.D., 2008, Basin-wide evaluation of the uppermost Green River Formation's oil-shale resource, Uinta Basin, Utah and Colorado: Utah Geological Survey Special Study 128, 19 p., 8 plates, <https://doi.org/10.34191/SS-128>.