INFORMATION SERIES 85

Colorado Mineral and Energy Industry Activities 2021-2022

by Michael K. O'Keeffe

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EXECUTIVE SUMMARY and TAX REVENUE

The Colorado Geological Survey (CGS) estimates the total value of 2021 mineral and energy fuels production in Colorado to be $20.51 billion, a ~70% increase from the 2020 estimate of $12.07 billion mainly due to higher average prices for oil and natural gas. In 2021, the top commodities produced in terms of production value include: oil, natural gas, coal, molybdenum, gold, sand and gravel, cement, industrial gases (carbon dioxide), and crushed stone. Estimated mineral production values for 2021 are shown by commodity type in **Figure ES-1**. Oil and natural gas production accounted for ~88% of Colorado's total mineral and energy production value in 2021. Estimated mineral and energy production values for 1994 through 2021 are shown in **Figure ES-2**.

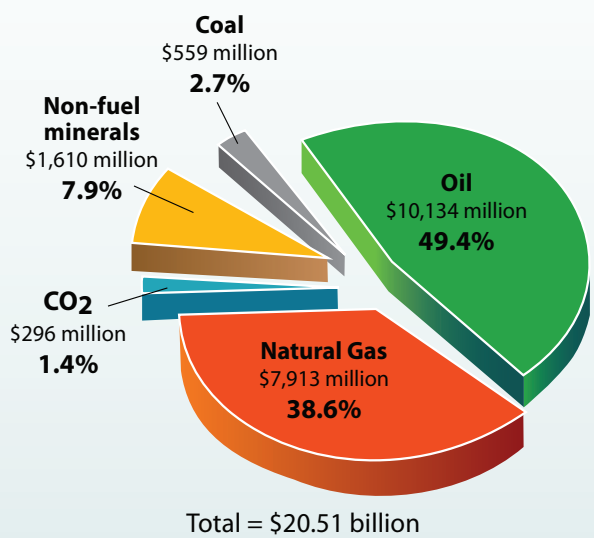


Figure ES-1. 2021 Colorado mineral production value by commodity type (U. S. dollars).

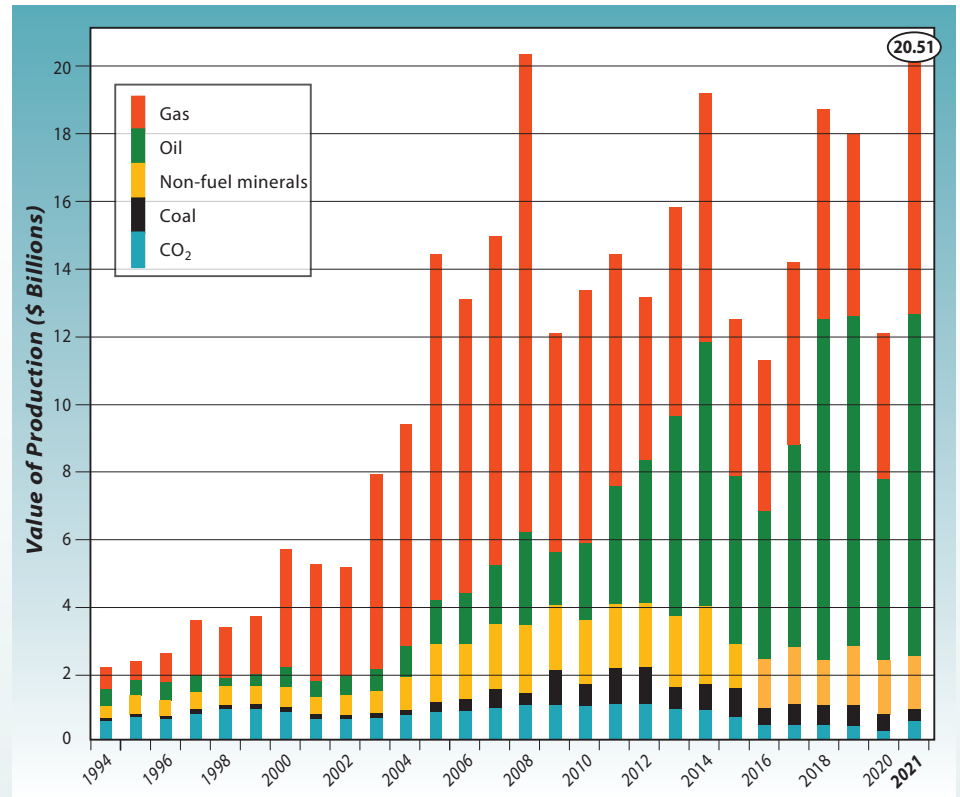


Figure ES-2. Mineral and energy fuel production value in Colorado, 1994–2021.

The total estimated value of Colorado oil and natural gas production in 2021 is ~$18.05 billion which is ~85% higher than last year's estimated value of $9.74 billion. Although 2021 oil and gas production decreased in Colorado, oil and natural gas production remains higher than historical values and production values have increased from 2016 due to higher prices and an increase in demand. Colorado has the eighth largest proven oil reserves and the ninth largest proven natural gas reserves in the U.S. (EIA, 2022a). The estimated value of Colorado coal production in 2021 is $559 million. The overall decreasing trend in coal production over the last several years is due primarily to the increased use of natural gas and renewable energy resources nationwide. In 2021, Colorado is the 11th largest coal producer in the U.S. (EIA, 2022b) with both underground and surface mines currently in operation west of the continental divide.

Non-fuel mineral production includes metals, aggregate, limestone, cement, industrial minerals (gypsum, nahcolite), and gases (carbon dioxide, helium). The total estimated value of Colorado's production of non-fuel minerals in 2021 is $1.61 billion (USGS, 2022a). Colorado is the third largest gold producer in the U.S., behind Nevada and Alaska, based on the total 2021 production from a single mine. Two Colorado mines continue to produce molybdenum and the state was the second largest producer of this metal in 2021 behind Arizona. Although Colorado has been a producer in the past, there was no uranium mine production in Colorado in 2021, however, several property transfers and exploration activities continued in 2021.

Carbon dioxide produced in Colorado is used primarily for enhanced oil recovery in the Permian Basin oil fields of Texas and New Mexico. The production value estimate for 2021 is $296 million. Helium is produced in Cheyenne County and other areas in Colorado, however, production estimates from these facilities are not available.

Severance taxes are state taxes collected on companies who produce nonrenewable resources including oil, gas, coal, molybdenum, and gold. Companies that extract these resources pay severance tax as well as other taxes including income, sales, and property taxes. A portion of the severance tax funds is distributed to counties, municipalities, and school districts. Severance tax funds are also used to support the CGS and other programs within the Colorado Department of Natural Resources (DNR). The distribution hierarchy of total collected state severance tax revenue is shown in **Figure ES-3**. The Colorado Legislative Council Staff provides a summary of severance tax rates, credits by mineral type, and distribution (Colorado General Assembly, 2022).

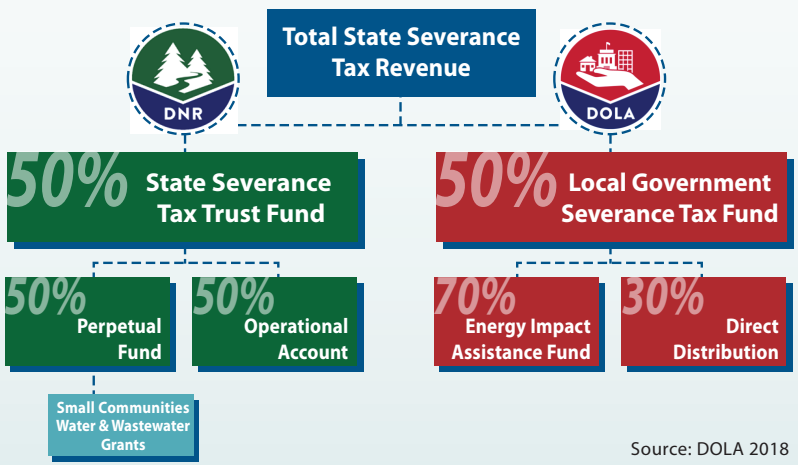


Figure ES-3. Distribution of state severance tax revenue in Colorado.

The Colorado Department of Local Affairs (DOLA) administers the distribution of severance tax revenue to county and local governments. In fiscal year (FY) 2020/2021 (20/21), July 1st through June 30th., Colorado was required to refund more oil and gas severance taxes than it collected. As a result, total FY 20/21 severance tax collections from metal, coal, and gas producers resulted in a negative collection of -$15.28 million (DOLA, 2021a; DOLA, 2021b) and a total severance tax distribution of ~1.24 million to counties. **Figure ES-4** shows the severance taxes collected by fiscal year since 1994. The negative oil and gas severance tax collection is associated with the amended tax returns filed in

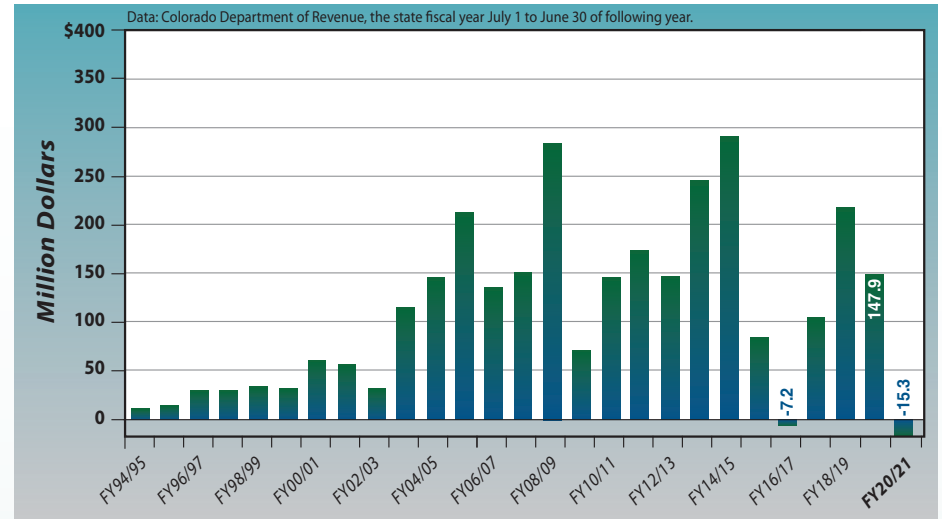


Figure ES-4. Colorado net severance tax collections FY94/95-FY20/21 (NOTE: In FY16/17 and in 20/21, severance refunds exceeded collections, hence the negative value).

response to a 2016 Colorado Supreme Court ruling. These factors are discussed in a previous mineral and energy industry activities (MEIA) report (O'Keeffe and others, 2018). In FY 21/22, ~$46.53 million of severance tax was distributed to counties. The map in **Figure ES-5** shows the distribution of severance taxes to each county in FY 21/22.

The State of Colorado owns ~2.8 million surface acres and ~4 million sub-surface (mineral estate) acres, of trust lands which are managed and leased by the Colorado State Land Board (SLB) (SLB, 2022a). Revenue generated by the SLB is held in public trusts that provide financial support to Colorado public schools and other public institutions. Trust lands are leased for several purposes that include mining and oil and gas. In FY 20/21, the Colorado state trust assets were valued at $4.3 billion and SLB assets generated $147 million (SLB, 2021b). The SLB provides funds for the Colorado Department of Education's Building excellent Schools Today (BEST) program that provides grants for construction of new schools or the renovation of existing facilities. In FY 20/21, the SLB provided $67 million to the BEST program (SLB, 2021b). Also, the SLB's financial assets are associated with the Public School Permanent Fund which provides revenue to Colorado public schools. In FY 20/21, the SLB received ~$88.2 million in mineral revenue (SLB, 2021c). The revenues include the following: oil and natural gas royalties and rentals, ~$81.57 million; coal, ~$2.46 million; other minerals, ~$2.32 million; and other revenues, ~$1.86 million (SLB, 2021c). **Figure ES-6** shows the SLB revenues from FY 96/97 to FY20/21.

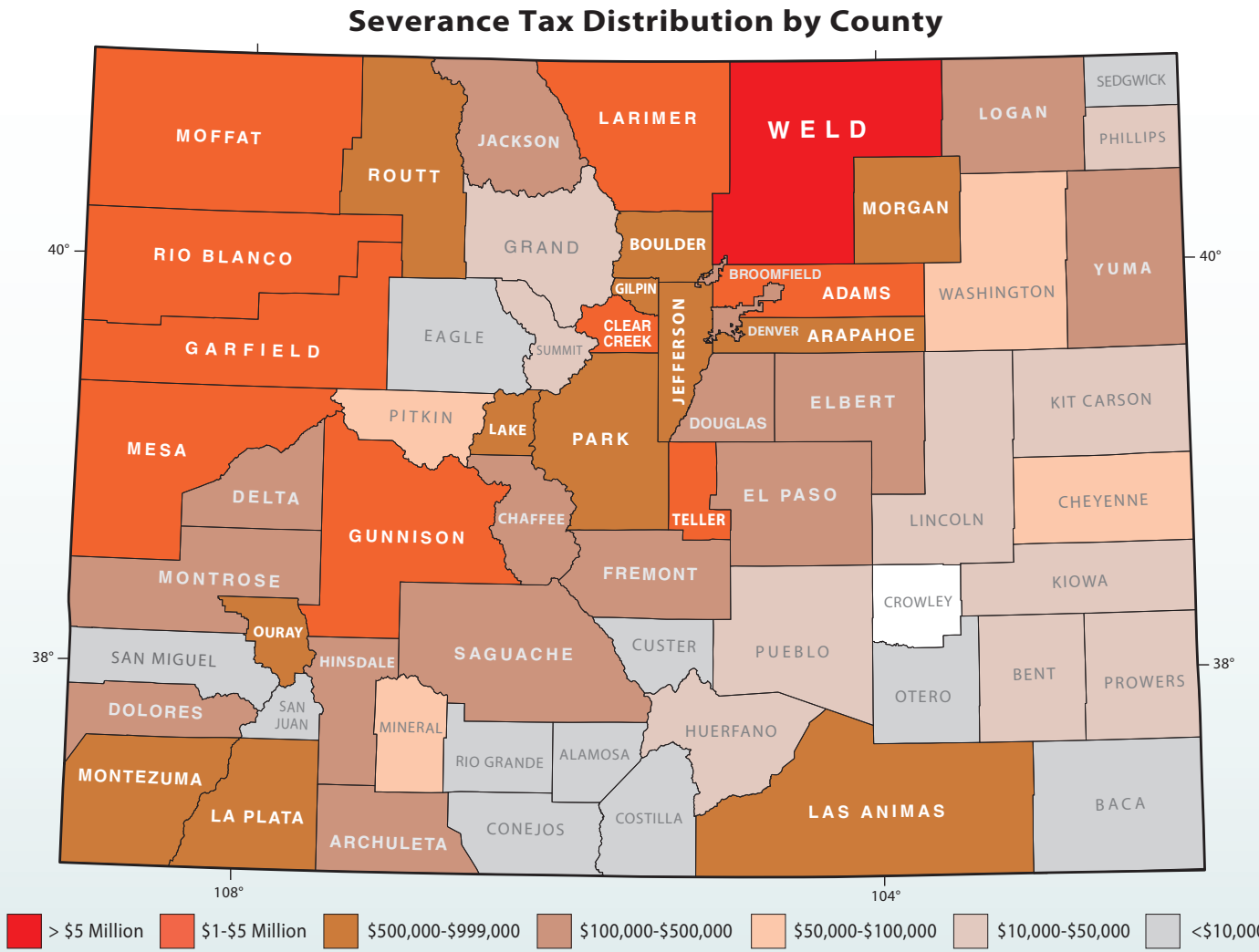


Figure ES-5. Colorado mineral severance tax distributions by county, FY 21/22.

Lands owned by the federal government make up over 35% of Colorado's acreage. The State of Colorado receives 50% of the rental, royalty, and bonus revenue from mineral and energy fuel leases on federal land. This includes bonus, rents, royalties, and other revenue associated with oil, gas, coal, oil shale, geothermal, and sodium (nahcolite) federal leases in Colorado. DOLA distributes a portion of these funds to local governments affected by mineral and energy development. In 2021, federal mineral lease revenues generated totaled ~$282 million with ~$106 million disbursed back to the state (U.S. Department of Revenue [USDR], 2022). **Figure ES-7** shows the revenue from federal mineral leases from 2009 to 2021.

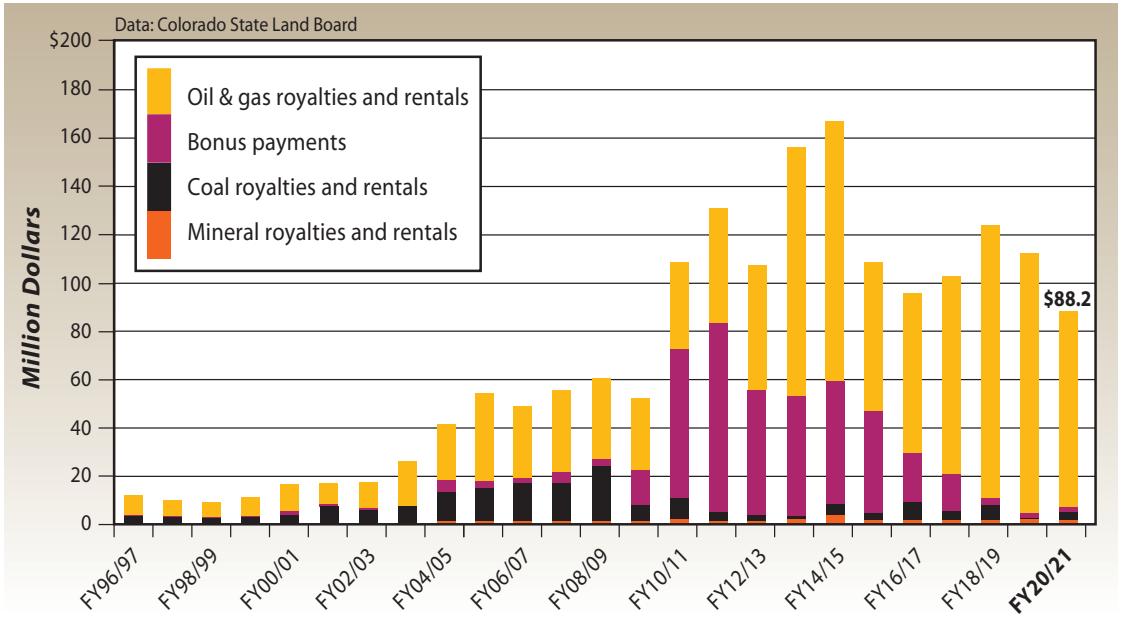


Figure ES-6. Colorado State Land Board (SLB) mineral revenues.

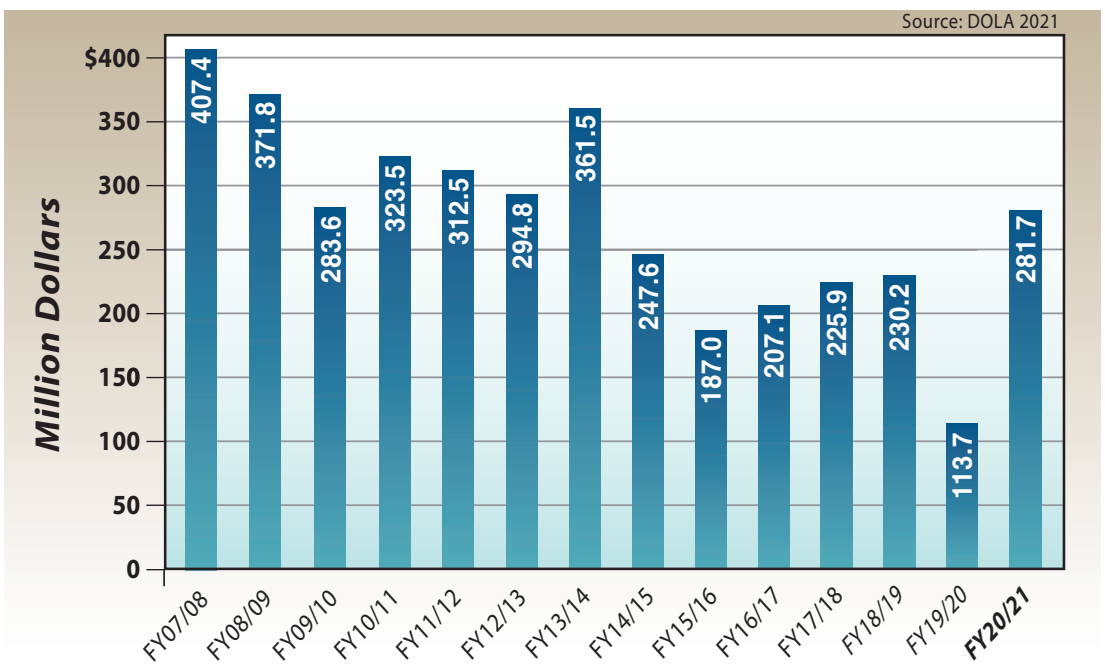


Figure ES-7. Federal mineral lease revenue generated in Colorado (50% is distributed to the state).

Oil and Natural Gas

Most of the drilling activity and production increases in the last several years are in unconventional reservoirs, especially in the Denver-Julesburg (DJ) Basin of northeastern Colorado. The map in **Figure 1** shows the major sedimentary basins in Colorado and the location of 2021 oil and natural gas approved drilling permits (COGCC, 2021a). According to the U.S. Department of Energy (DOE) Energy Information Agency (EIA), ~64% of the total U.S. crude oil production in 2021, ~2.64 billion barrels, was produced from tight oil formations (EIA, 2022c). Hydraulic fracturing and horizontal drilling techniques allow relatively cheap production from unconventional reservoirs which include shale, sandstone, and carbonate rock formations with low permeability (EIA, 2022c). The DJ Basin includes unconventional oil and gas resources in the Upper Cretaceous Niobrara Formation which has been a target of more recent exploration to the northeast of Denver.

Crude oil prices increased in 2021 and continued to increase in 2022 (FERC, 2022). Average annual oil prices decreased in

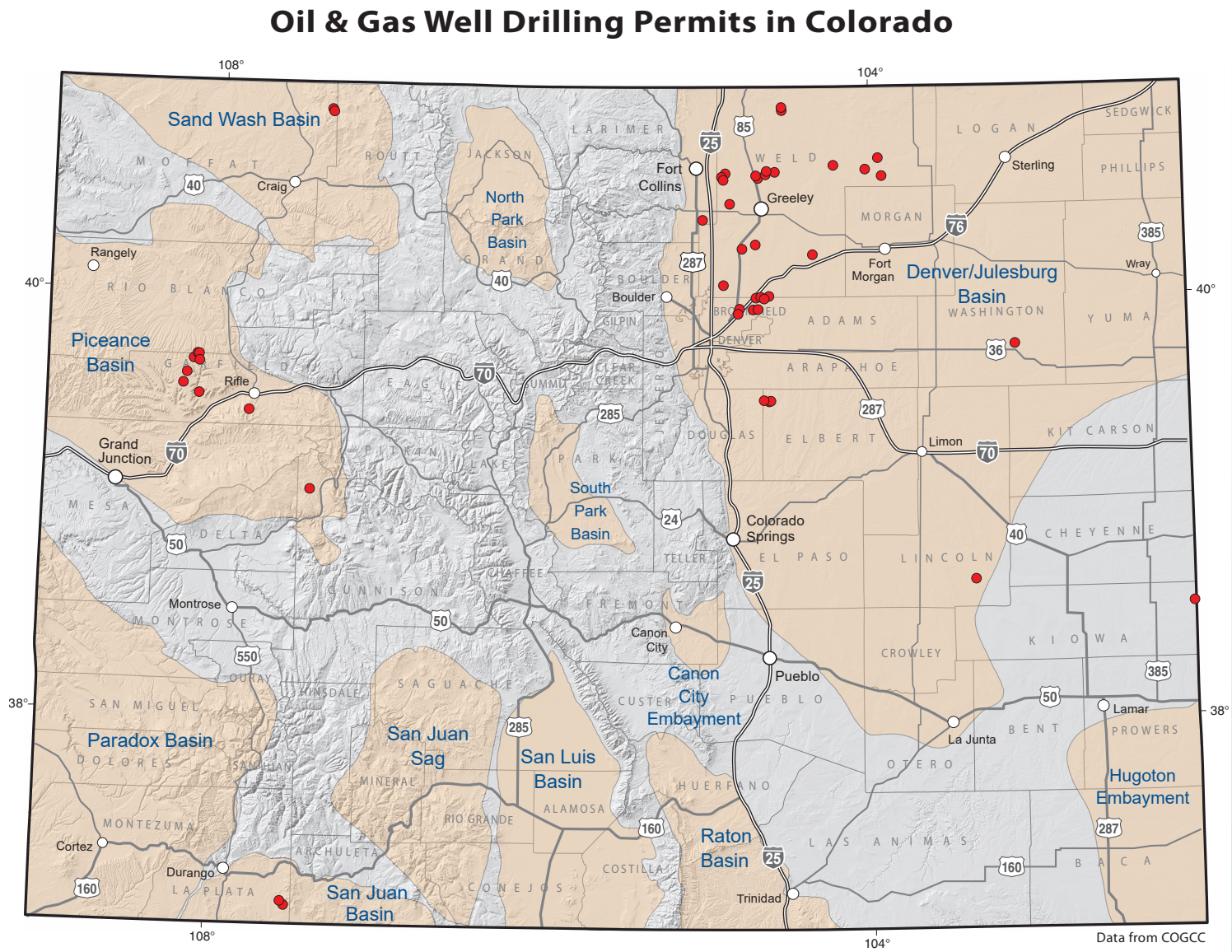


Figure 1. Sedimentary basins and the location of oil and gas well drilling permits (red dots) approved January 2021 to December 2021.

2020 to $31.40 per barrel (EIA Colorado Domestic Crude Oil First Purchase Price) from an average of $50.89 in 2019 (EIA, 2021d). The average annual oil price dramatically increased in 2021 to $65.94 per barrel (EIA, 2022d). Using this price and the Colorado Oil and Gas Conservation Commission (COGCC) production estimate (COGCC, 2022b), the estimated overall oil production value in 2021 for Colorado is $10.13 billion, an increase of ~88% when compared to the 2020 estimated oil production value of $5.39 billion (**Figure 2**) (O'Keeffe, 2022). Estimated oil production in Colorado between 2020 and 2021 decreased by over 17.8 million barrels to ~153.7 million barrels. Oil production in Colorado and the average annual price per barrel over time are shown in **Figure 3**. At the end of 2021, Colorado ranked eighth among the top ten states with estimated proven oil reserves of ~1.169 billion barrels of oil (BO) (**Figure 4**). Texas ranked first with estimated proven oil reserves of 16.689 BO (EIA, 2022e).

The 2021 average spot price for natural gas was $4.04 per thousand cubic feet (Mcf) (based on a heat content of 1.039 British Thermal Units per Mcf) (EIA, 2022f) (**Figure 5**). This natural gas price is ~92% higher than the 2020 average spot price of $2.11 Mcf reported last year (O'Keeffe, 2022). As reported by FERC (2022, page 2), *"Natural gas prices increased in 2021 as higher demand, fueled primarily by LNG (liquid natural gas) export demand growth, outpaced production growth. Average electricity prices also increased,*

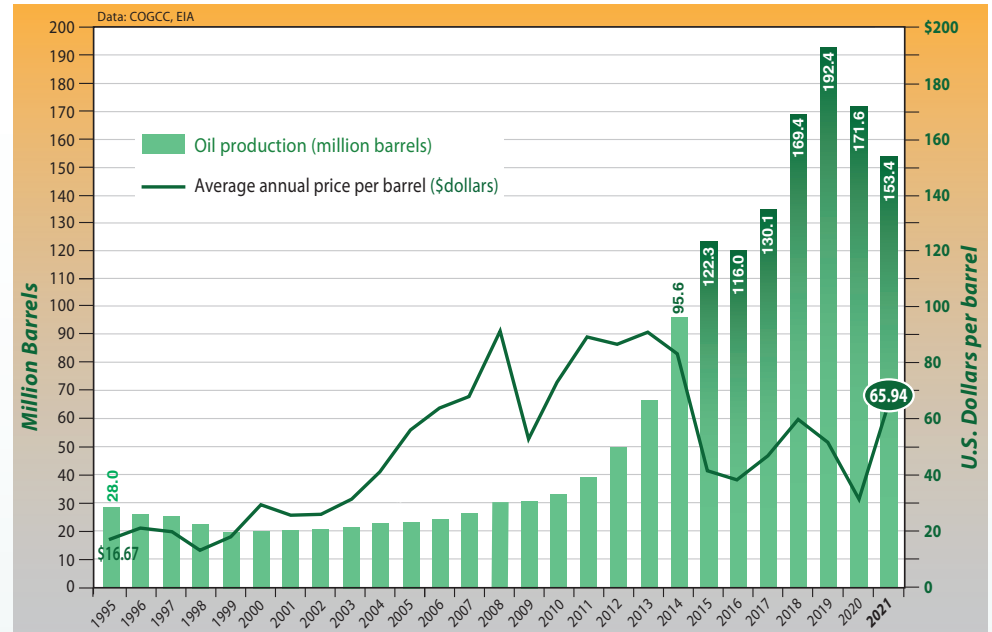


Figure 3. Colorado oil production and average annual price per barrel, 1995–2021.

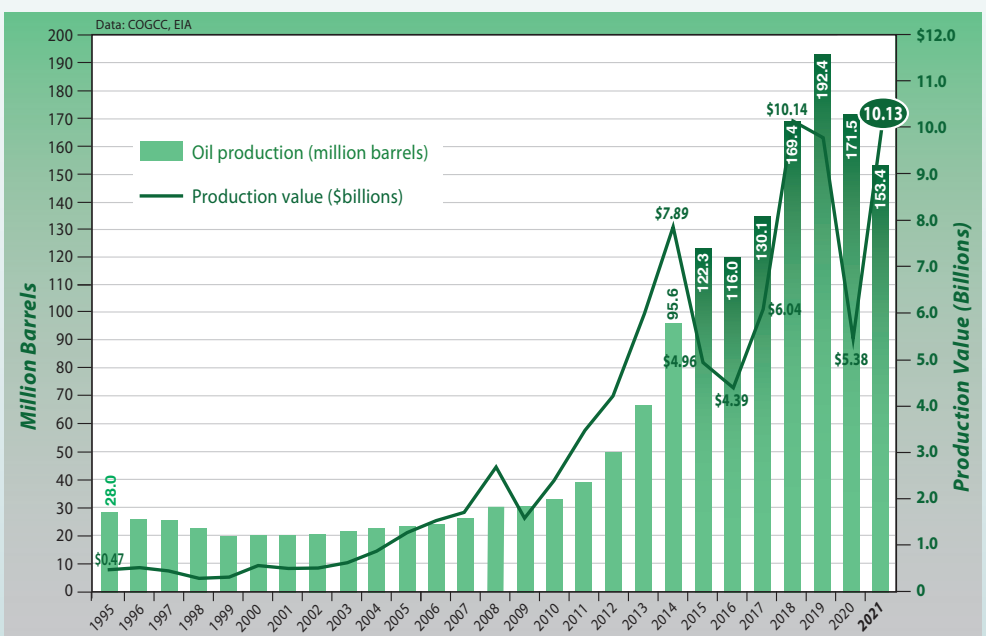


Figure 2. Oil production and estimated production value in Colorado, 1995–2021.

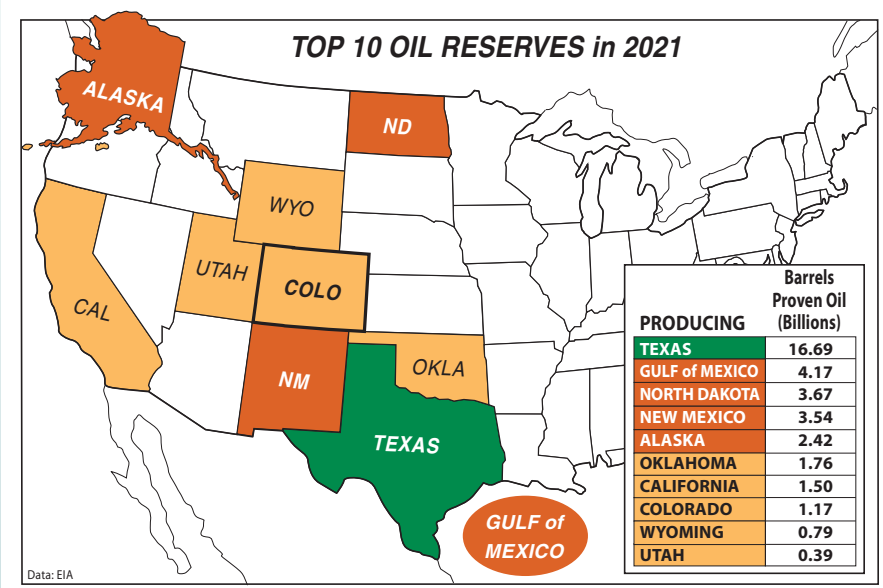


Figure 4. Top 10 states with proven oil reserves in 2021.

driven by higher natural gas prices and rising demand. Electricity and natural gas demand rebounded as the economy recovered from the impacts of the COVID-19 pandemic." According to the EIA (2022g), U.S. natural gas annual production in 2021 was the highest on record since 1936. Colorado's natural gas production decreased from ~2,064 billion cubic feet (Bcf) in 2020 to ~1,958 Bcf in 2021.

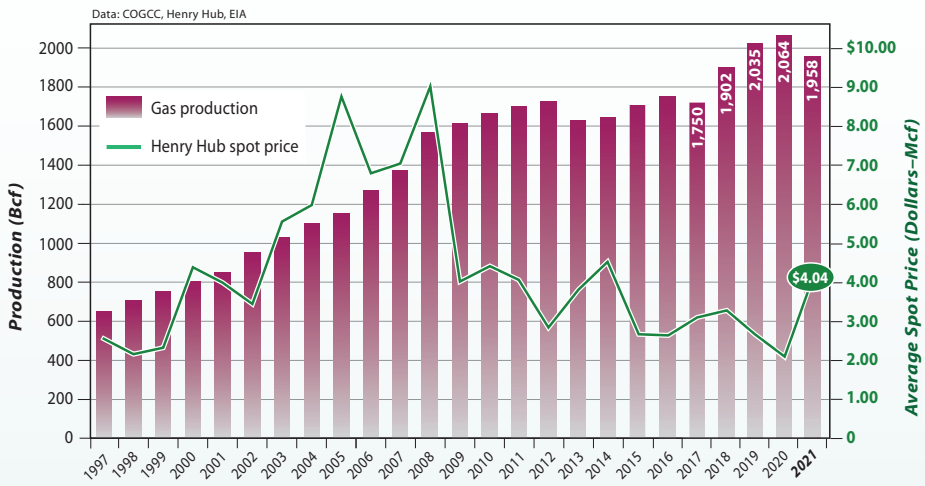


Figure 5. Colorado natural gas production and average price, 1997-2021.

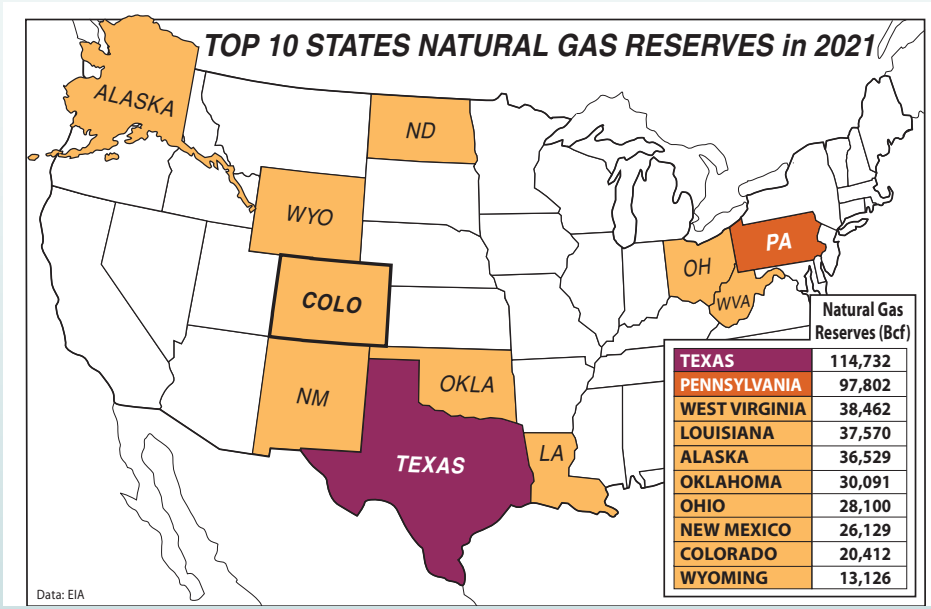


Figure 6. Top 10 states with proven natural gas reserves in 2021 (years end).

The estimated total 2021 natural gas production value in Colorado, using the Henry Hub spot price (EIA, 2022f) and COGCC production data (COGCC, 2022b), is $7.91 billion. This is an increase of ~82% compared to the 2020 estimated natural gas production value of $4.35 billion (O'Keeffe, 2022). At the end of 2020, Colorado had estimated proved natural gas resources of 20,412 Bcf, which was the ninth largest in the U.S. (EIA, 2022e) (**Figure 6**). Texas ranked first with estimated proved natural gas reserves of 114,732 Bcf (EIA, 2022e).

As presented in earlier CGS MEIA reports (O'Keeffe, 2022), the U.S. Geological Survey (USGS) released several updated oil and gas assessments for other geological formations in Colorado. The USGS national oil and gas assessments can be accessed on their interactive online map (USGS, 2022b). The Colorado assessments are summarized below.

- An updated Mancos Shale oil and gas potential assessment for the Piceance Basin located in central and northwestern Colorado (USGS, 2016) assessed undiscovered and technically recoverable resources in the Late Cretaceous Mancos Shale. The report states that the Mancos Shale within the Piceance Basin contains 66.3 trillion cubic feet (Tcf) of natural gas, 74 million BO, and 45 million barrels of natural gas liquids (USGS, 2016).

- In 2019, the USGS released assessments of undiscovered continuous tight-gas resources in the Mesaverde Group and Wasatch Formation located in the Uinta-Piceance Province of Utah and Colorado (USGS, 2019). This assessment includes the Williams Fork Formation and overlying Wasatch Formation (including the Cameo-Fairfield coal and carbonaceous shale deposits) in the Piceance Basin located in western Colorado (Figure 1). For the Piceance Mesaverde tight-gas system, the USGS estimated undiscovered, technically recoverable mean resources of 4.7 Tcf of natural gas (USGS, 2019).

- In 2020, the USGS released updated assessments of undiscovered oil and gas resources in the Mancos-Menefee composite, Todilito, Lewis Shale, and Fruitland total petroleum systems located in the San Juan Basin of New Mexico and Colorado (USGS, 2020a; 2020b; 2020c). Part of the San Juan Basin extends into southwestern Colorado as shown in Figure 1. The USGS reported the following estimated undiscovered, technically recoverable mean resources in each system:

    - Mancos-Menefee composite (includes the Dakota Sandstone, Gallup Sandstone, Mancos Shale and associated sandstones, Mesaverde Group) and Todilito (Todilito Limestone Member of the Wanaka Formation and underlying Entrada Sandstone) systems = 27 Tcf of natural gas, 12 million BO, and 142 million barrels of natural gas liquids (USGS, 2020a).

- Lewis Shale system = 2.6 Tcf of natural gas and 3 million barrels of natural gas liquids (USGS, 2020b).
- Fruitland system (includes the Fruitland Formation, Pictured Cliffs Sandstone, overlying Tertiary sandstones) = 39 Tcf of natural gas and 49 million barrels of natural gas liquids (USGS, 2020c).

Coalbed Methane

Figure 7 shows Colorado's annual coalbed methane (CBM) production versus conventional natural gas over time. CBM is a type of natural gas, mainly methane with minor amounts of hydrocarbons and other gases, that is generated and stored in coal beds (Zou, 2017). CBM production in Colorado reached its highest level, 59%, of the total natural gas production during 1998 and has continuously declined to ~10.5% of the total natural gas production (206 Bcf) in 2010 (COGCC, 2022a). This decline is largely due to the increase of natural gas production of unconventional reservoirs by the using horizontal drilling and hydraulic fracturing techniques.

County Rankings – Oil and Natural Gas Production

According to the EIA, Colorado produced about four times more crude oil between 2010 and 2021 mostly due to the increased use of horizontal drilling and fracturing techniques (EIA, 2022g). Thirty-six of Colorado's 64 counties produced crude oil and/or natural gas in 2021. To rank each county's contribution to the state's total production value, production from each county was multiplied by average annual prices. We used the EIA's 2021 "Colorado First Purchase" price of $65.94 per BO for the average annual price of oil (EIA, 2022d) and the average spot price for natural gas of $4.04 per Mcf (EIA, 2022f). The total 2021 estimated oil and natural gas production value for Colorado is ~$18.04 billion. **Figure 8** shows the estimated total oil and natural gas production value by county.

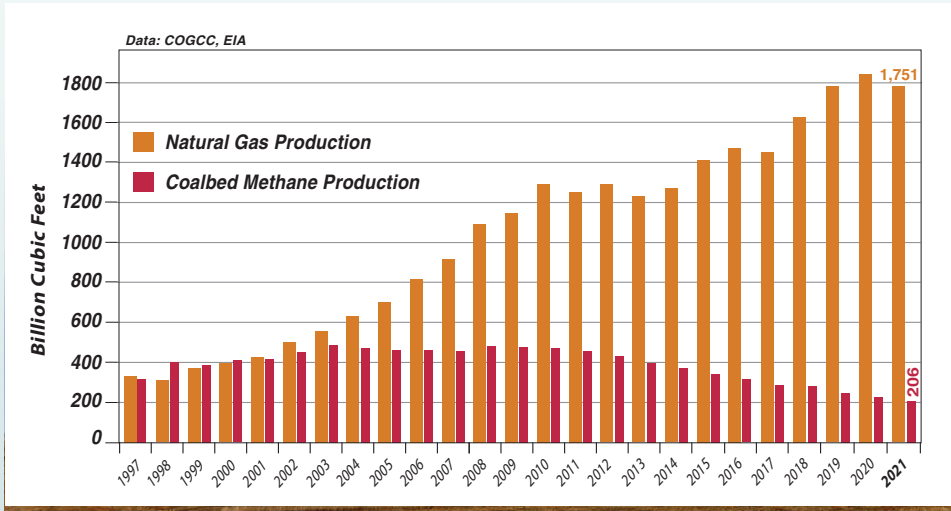


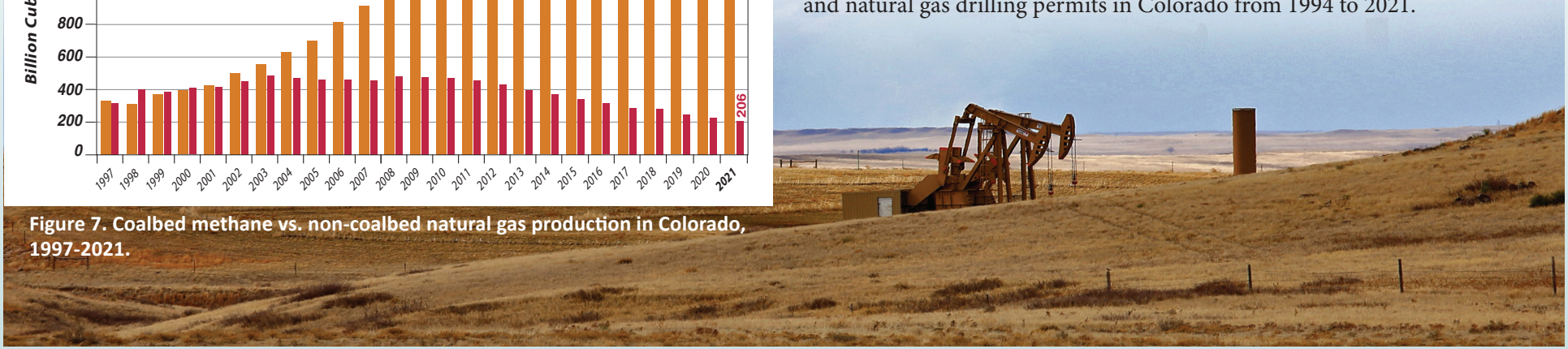
Figure 7. Coalbed methane vs. non-coalbed natural gas production in Colorado, 1997-2021.

Weld County is the single largest producer of oil and natural gas in Colorado with an estimated total production value of ~$12.716 billion in 2021. A large portion of more recent crude oil production is from the Upper Cretaceous Niobrara Formation in Weld County which is within the DJ Basin (Figure 1) and Wattenberg Field. This field is the fourth largest U.S. oil field and ninth largest gas field based on proved reserves (EIA, 2022g). The Wattenberg Field has been one of the most important oil and gas reservoirs in Colorado for the last 50 years where several conventional and unconventional resources have been developed since its discovery in 1970 (Sonnenberg, 2016).

Garfield County has the second largest natural gas and oil production value with an estimated total of $1.728 billion. La Plata County ranks third in natural gas and oil production value with an estimated total of ~$909 million. Adams and Rio Blanco counties have a combined oil and natural gas production value of $1.33 billion. **Figures 9 and 10** show the estimated oil and natural gas production by county for 2021, respectively.

Drilling Permits

Weld County remains the center for new oil and gas drilling permits with lesser amounts in other oil and natural gas producing counties. Data shows that COGCC received 686 applications for drilling permits in 2021 (COGCC, 2022c), a ~49% decrease from 2020. **Figure 11** shows the number of annual oil and natural gas drilling permits in Colorado from 1994 to 2021.



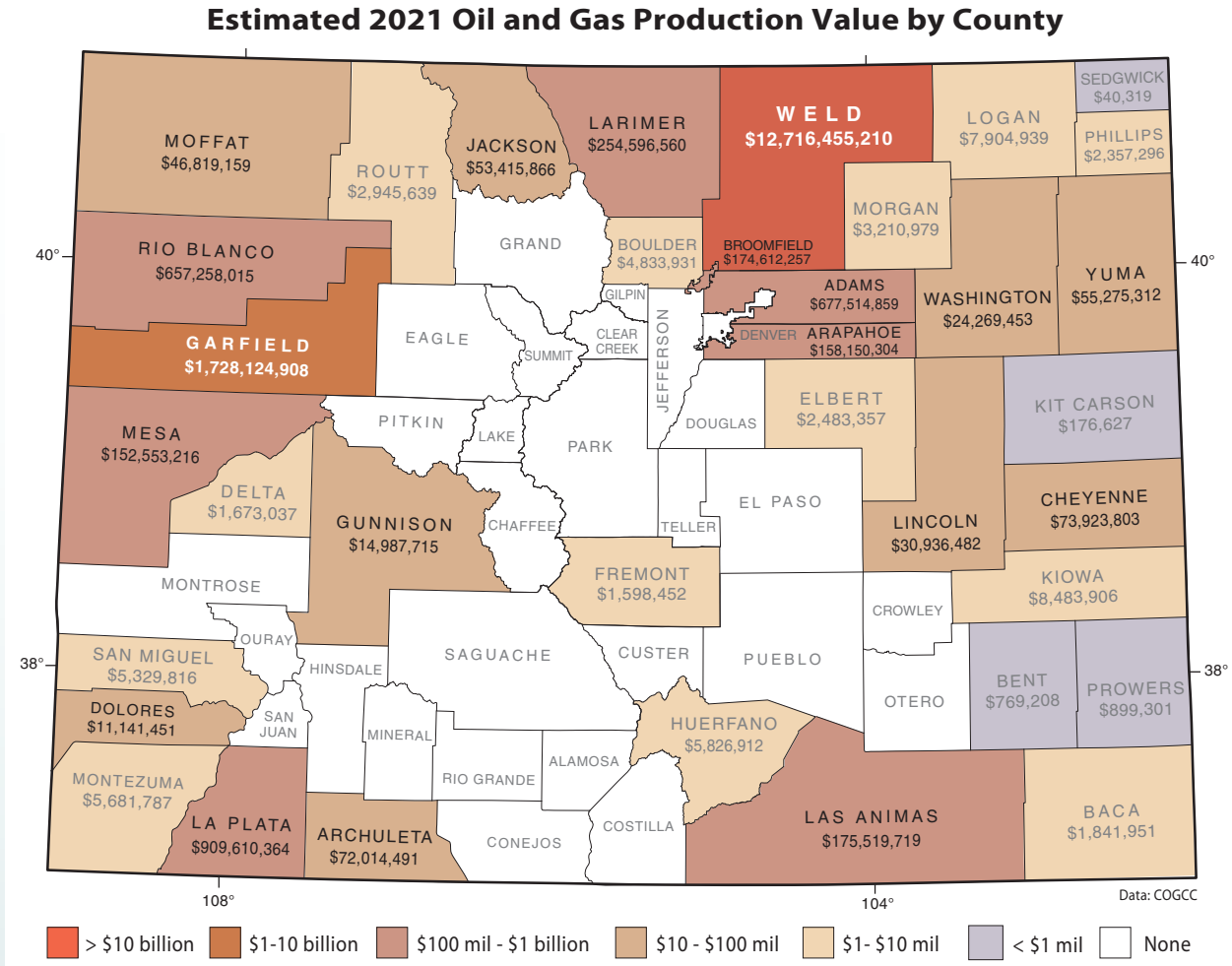


Figure 8. Estimated oil and natural gas production value by county in Colorado, 2021.

Oil Shale

Oil shale is different from oil produced from shale reservoirs.": Currently, oil shale resources have not been developed in Colorado. As reported previously (Guilinger and Keller, 2015), more than half of the world's known oil shale resources are in the Eocene Green River Formation, which covers ~16,000 square miles in the Green River Basin in Wyoming, the Piceance Basin in Colorado, and the Uinta Basin in Utah. The Green River Formation was deposited in an ancient lake, known as Lake Gosiute, which occupied varying parts of these basins from between ~52.5 to 47.5 million years ago (Smith and others, 2008). Oil shale is different from oil produced from shale reservoirs. Recovery of oil from oil shale is more difficult and expensive than oil from conventional or unconventional petroleum resources. Heat applied to the kerogen layers (solid bituminous material) releases the oil allowing the product to flow. Estimates show the kerogen may contain 4.285 trillion barrels of recoverable oil (USGS, 2013). The Piceance Basin, a subbasin within the Greater Green River Basin, has an estimated 1.525 trillion BO of this potential resource with ~920 billion BO in place at an oil yield of 15 gallons per ton (gpt) or greater and ~352 billion BO at an oil yield of 25 gpt or greater (USGS, 2013). For more details about this assessment, see Johnson and others (2011).

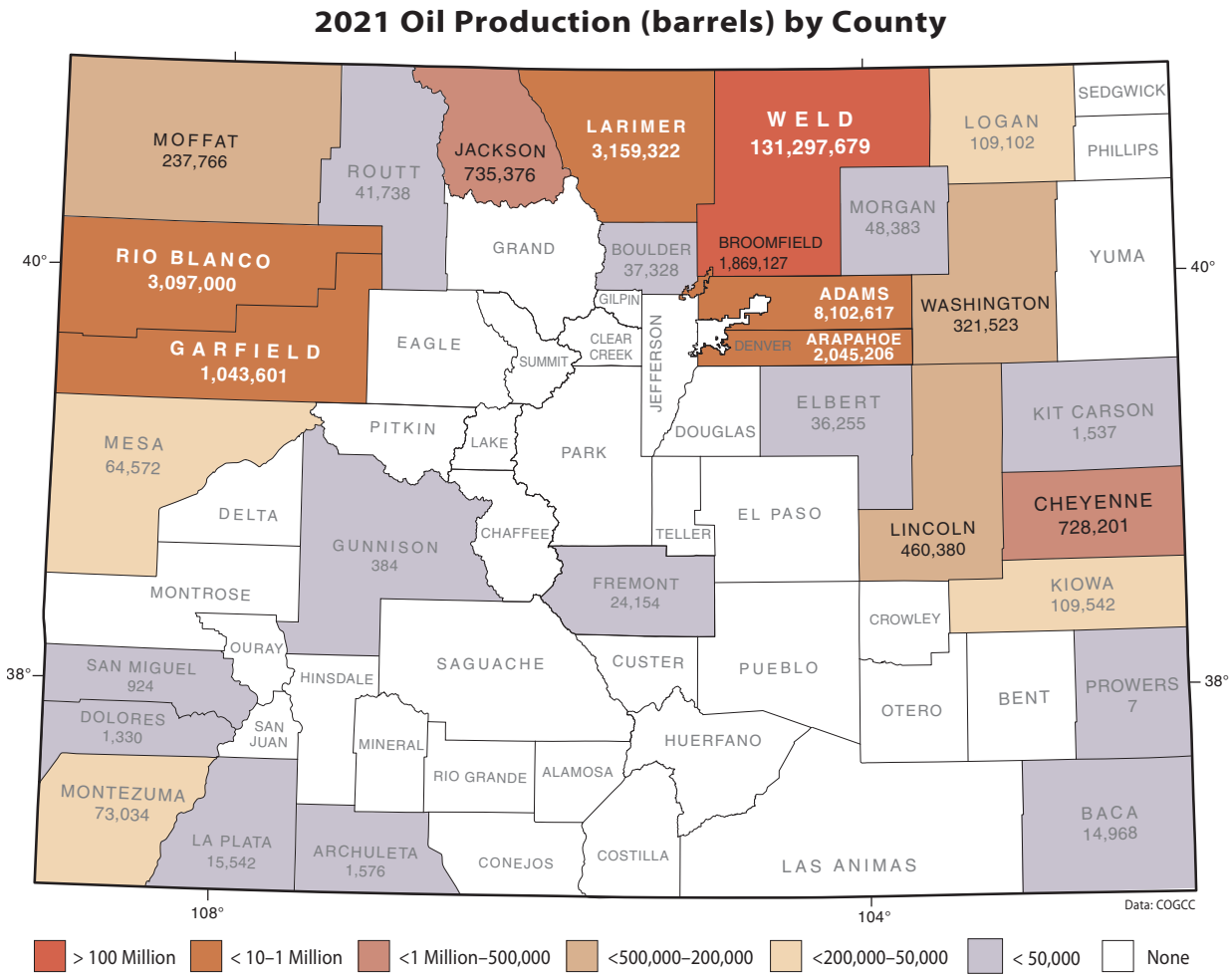


Figure 9. Total oil production by county in Colorado, 2021.

COGCC Regulations

As reported in previous MEIA reports (O'Keeffe, 2022), Colorado Senate Bill (SB) 19-181 passed in 2019 requires the COGCC to place more emphasis on public and environmental health and safety and addressing cumulative impacts from oil and gas activities. Additionally, the new law shifted the agency's mission from "fostering" the responsible development of oil and gas resources to "regulating" oil and gas development "in a manner that protects public health, safety, welfare, the environment and wildlife resources" (O'Keeffe, 2022). The COGCC worked on rule and policy changes associated with implementing SB19-181 since 2019. This included several rule-making hearings which included public comments and testimonies associated with changes to the COGCC regulations to meet SB19-181. In late 2020, the COGCC adopted these new rules which became effective in January 2021 (COGCC, 2022c). The COGCC provides the details and summary documents on the rule making hearings and rule/policy changes on their website (https://cogcc.state.co.us/#/home). In 2021, the COGCC continued work to implement the new rules and held weekly and monthly meetings to assist stakeholders with the new requirements and guidance documents. Current and past rulemaking documents are also available on their website (COGCC, 2022d):

https://cogcc.state.co.us/hearings.html#/rulemaking

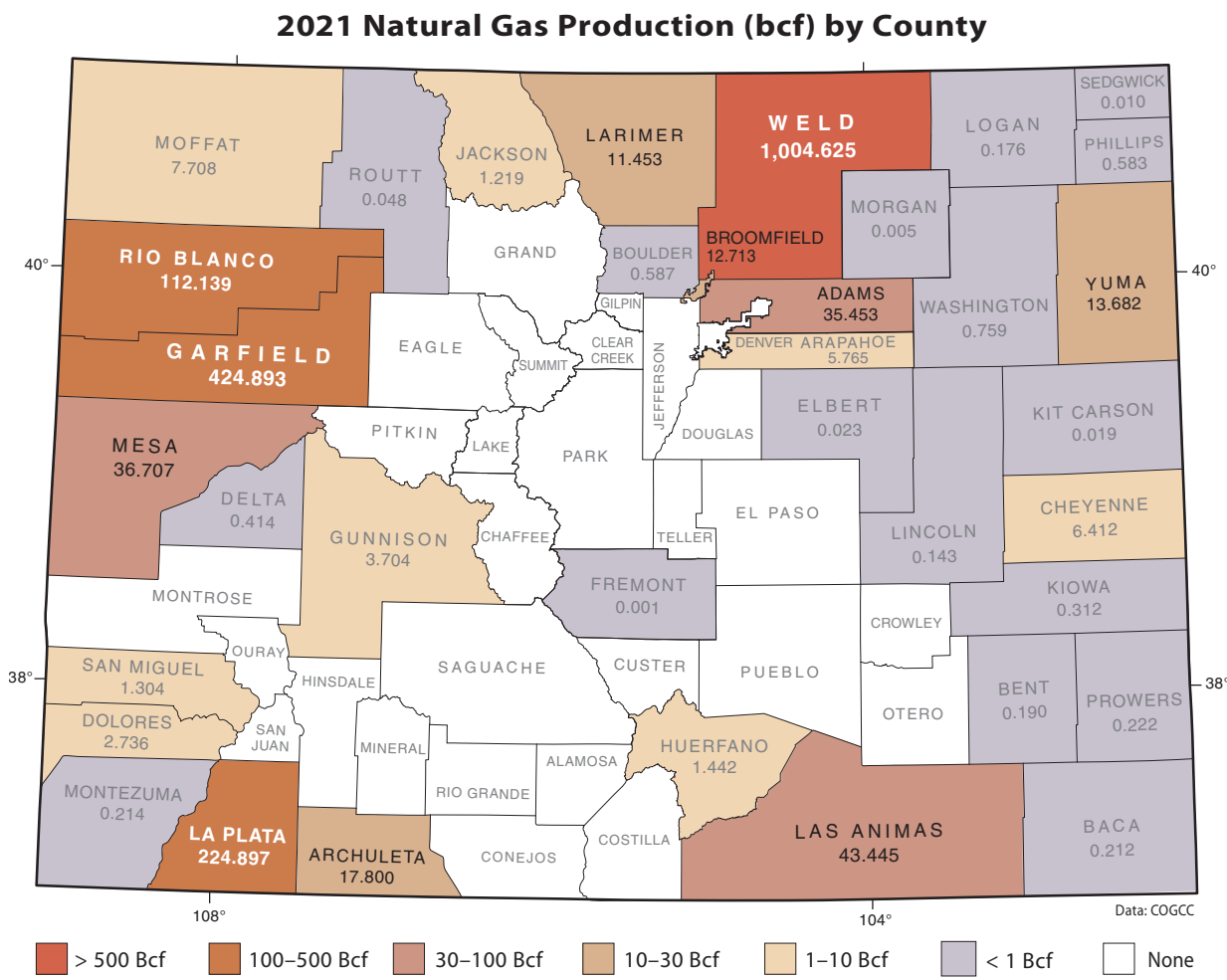


Figure 10. Total natural gas production by county in Colorado, 2021.

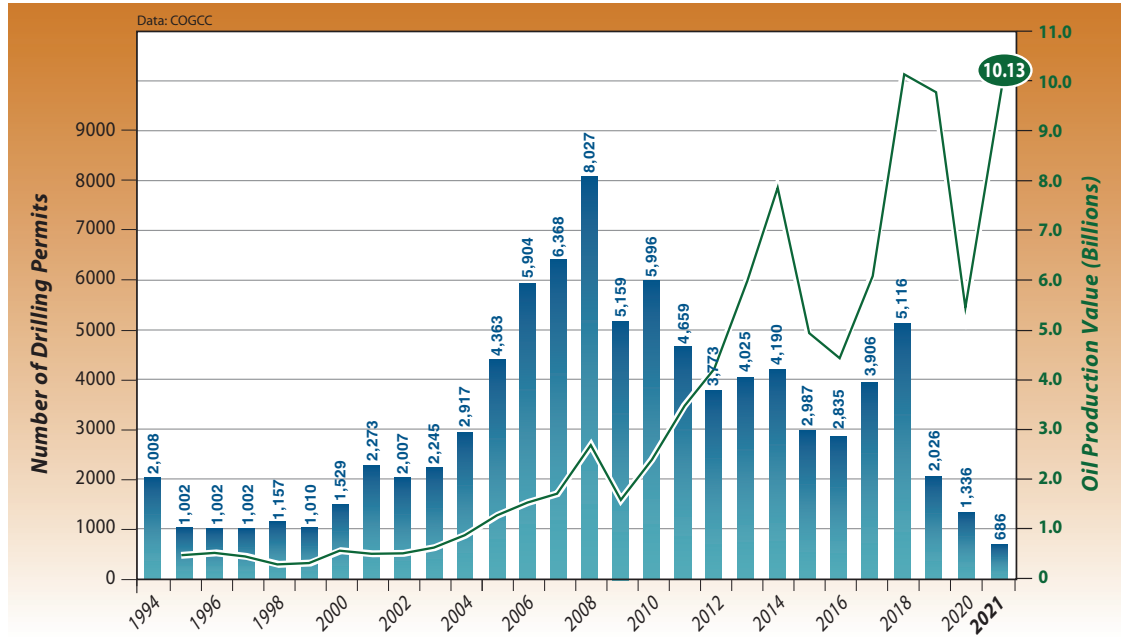


Figure 11. Annual oil and gas drilling permits and oil production value in Colorado, 1994-2021.

CONVENTIONAL ENERGY RESOURCES: COAL

Coal production in the U.S. decreased 22.3% in 2021 compared to 2019. There was a slight increase (7.8%) in U.S. coal production between 2020 and 2021 (EIA, 2022b), due to an increase in foreign demand for coal. Although U.S. coal production has generally decreased since 2012, coal is still a significant source of Colorado's electrical power. In 2021, coal-fired plants provided about 40% of Colorado's electricity (EIA, 2022g) while 35% of electric generation was from renewable sources, especially wind and solar power (EIA, 2022g). For comparison, in 2015, 60% of the electricity generated in Colorado came from coal. The general decline of the use of coal for electricity generation is due to lower natural gas prices, federal greenhouse gas regulations and taxes designed to cut carbon dioxide emissions, government subsidies, and the growing use of renewable energy sources.

Between 2011 and mid-2020, 96 gigawatts (GW) of coal electricity generating capacity were retired in the U. S., or switched to another fuel (EIA, 2020a). In 2021, the EIA reported that power plants plan to retire 28% (59 GW) of the current coal-fired power capacity by 2035 (EIA, 2021a). These closures will decrease the U.S. coal electricity generating capacity to less than 200 GW which is a ~36% decrease compared to its peak of 314 GW in 2011 (EIA, 2020a). As of September 2021, 212 GW of coal-fired generating capacity was operating in the U.S. (EIA, 2021a).

In 2010, Colorado passed the Clean Air, Clean Jobs Act which promotes the replacement of Front Range coal-fired power plants with natural gas plants. Since 2010, utilities have shut down several coal-fired plants and other units have been converted to natural gas as follows:

- Between 2012 and 2013, utility companies shut down the Arapahoe Station in Denver, the Clark Plant in Cañon City, and the Cameo Station power plant near Grand Junction.
- In 2017, Xcel Energy (Xcel) converted the last remaining coal-fired unit at Cherokee Generating Station in Denver to natural gas and announced they would close three coal-burning units at the Comanche Generating Station in Pueblo (Unit 1 by 2022, Unit 2 by 2025, and Unit 3 by 2031) (Denver Post, 2017; Xcel, 2022).
- In 2019, the Tri-State Generation and Transmission Association officially retired the 100-megawatt Nucla Station power plant.
- In 2020, the Craig Generating Station in Moffat County announced it would close coal-fired units 1, 2, and 3 by 2025, 2028, and 2030, respectively (IEA, 2020).
- In early 2021, Xcel Energy announced that Hayden Generating Station in Moffat County would close coal-fired Unit 1 by the end of 2028 and Unit 2 by the end of 2027 (Xcel, 2022).
- In 2021, the Martin Drake power plant retired its coal-fired unit (ceased coal-fired unit in August 2021) and plans on shifting to natural gas (CPR, 2021) and the Pawnee Station will convert to natural gas by 2026 (Xcel, 2022).

Power generation in Colorado consumes about 64% of the coal mined in the state. The rest is shipped to ~16 other states or exported to other countries (~1.7 million tons in 2021) (EIA, 2022h). Colorado has some of the cleanest burning coal (low-sulfur and mercury content) in the U.S. and several CGS publications include summary information about Colorado's coal quality compared to other regions (Carroll, 2004). Coal production from Colorado mines in 2021 is 12.14 million tons (DRMS, 2022a). The estimated value of Colorado coal production in 2021 is $559 million (**Table 1 and Figure 12**) and the estimated average value of a ton of Colorado coal is $46.02 (EIA, 2022b). Colorado coal production and average prices since 2004 are shown in **Figure 13**. In 2021, seven Colorado coal mines were active (**Table 2**) employing 957 coal miners (DRMS, 2022a) (**Figure 14**). In 2021, Colorado was ranked 11th in coal production in the U.S. (**Figure 15**) (EIA, 2022b). Wyoming, the leading U.S. producer by far (~238.8 million tons), mined over 20 times as much coal as Colorado. The locations of Colorado's active coal mines, coal-fired power plants, coal types and regions, and estimated coal-fired closing dates are shown on **Figure 16.**

In September 2020, the DOE announced the availability of $122 million in federal funding for research and development into carbon-ore, rare earths, and critical minerals (CORE-CM) projects focused on developing domestic supplies of these resources and creating new marketing opportunities for coal (DOE, 2020a). In April 2021, the DOE awarded $19 million for thirteen CORE-CM projects across the U.S. to support production of rare earth elements (REEs) and critical minerals from coal (DOE, 2021). Two projects in Colorado include a study lead by the University of Wyoming and by the University of Utah in the Greater Green River and Uinta coal regions (Figure 16), respectively. The CGS and the Colorado School of Mines are working with both parties and coal mines to perform an assessment of REEs and critical minerals in coal and coal combustion residuals within these regions. For more information about the Greater Green River CORE-CM project see the University of Wyoming's Center for Economic Geology Research web page: https://www.uwyo.edu/cegr/research-projects/core-cm-ggrb.html.

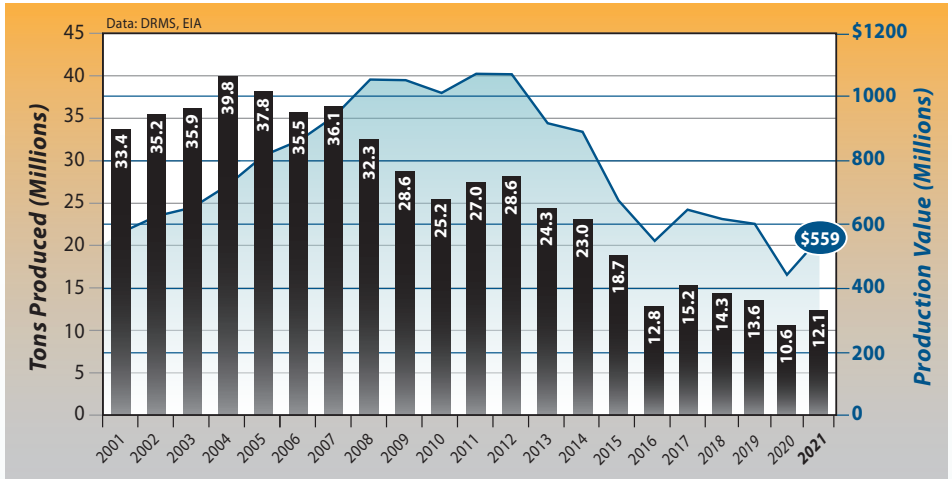


Figure 12. Production and value of coal mined in Colorado, 2001–2021.

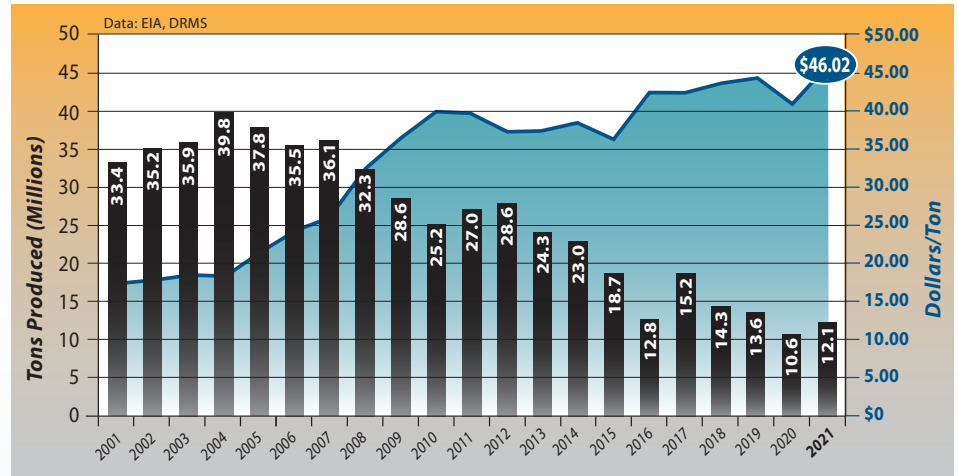


Figure 13. Coal production and average annual coal price in Colorado, 2001–2021.

Table 1. Coal production, price, value, and employment, 2002–2021.

Year	Production Tons (Millions)	Colorado Average Annual Coal Price $/Ton	Product Value (Millions)	Coal Miner Employment
2002	35.20	$17.72	$624	1,854
2003	35.88	$18.21	$653	1,859
2004	39.81	$18.10	$721	1,903
2005	37.82	$21.63	$818	1,963
2006	35.49	$24.27	$861	2,065
2007	36.14	$25.99	$939	2,069
2008	32.34	$32.67	$1056	2,124
2009	28.58	$36.71	$1049	2,247
2010	25.21	$40.00	$1008	2,061
2011	27.03	$39.88	$1078	2,254
2012	28.64	$37.54	$1075	2,279
2013	24.27	$37.58	$912	1,857
2014	22.98	$38.64	$888	1,512
2015	18.73	$36.12	$676	1,326
2016	12.80	$42.54	$499	1,211
2017	15.18	$42.52	$645	1,119
2018	14.28	$43.30	$618	1,160
2019	13.63	$44.21	$602	1,098
2020	10.63	$41.45	$441	901
2021	12.14	$46.02	$559	957

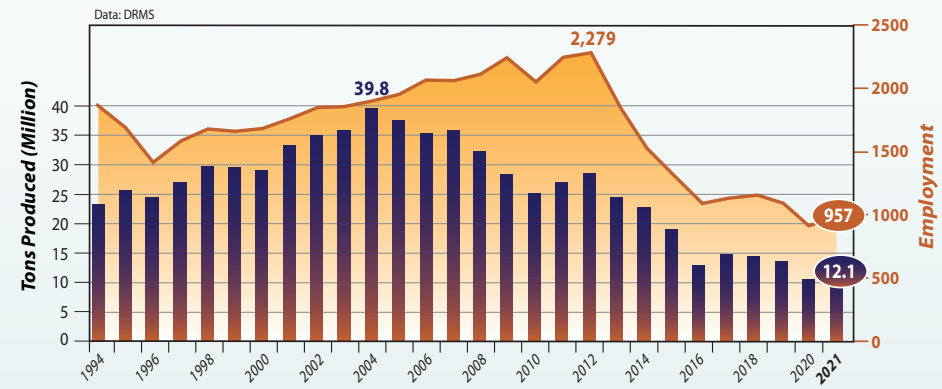


Figure 14. Coal production and employment in Colorado, 1994–2021.

Table 2. Active coal mines in Colorado, 2021.

Mine	Operator	County	Mine Type	2021 Prod. (tons)
New Elk Mine	Basin Resources	La Animas	Underground	167,380
Colowyo	Colowyo Coal Co. L.P.	Moffat	Surface	2,198,005
Deserado	Blue Mountain Energy	Rio Blanco	Underground	2,711,295
Foidel Creek	Twentymile Coal Co./Peabody Energy	Routt	Underground	1,739,111
King II	GCC Energy LLC	La Plata	Underground	466,410
Trapper	Trapper Mining Inc.	Moffat	Surface	1,574,787
West Elk	Mountain Coal Co./Arch Coal	Gunnison	Underground	3,282,254
Total				**12,139,242**

Data: DRMS

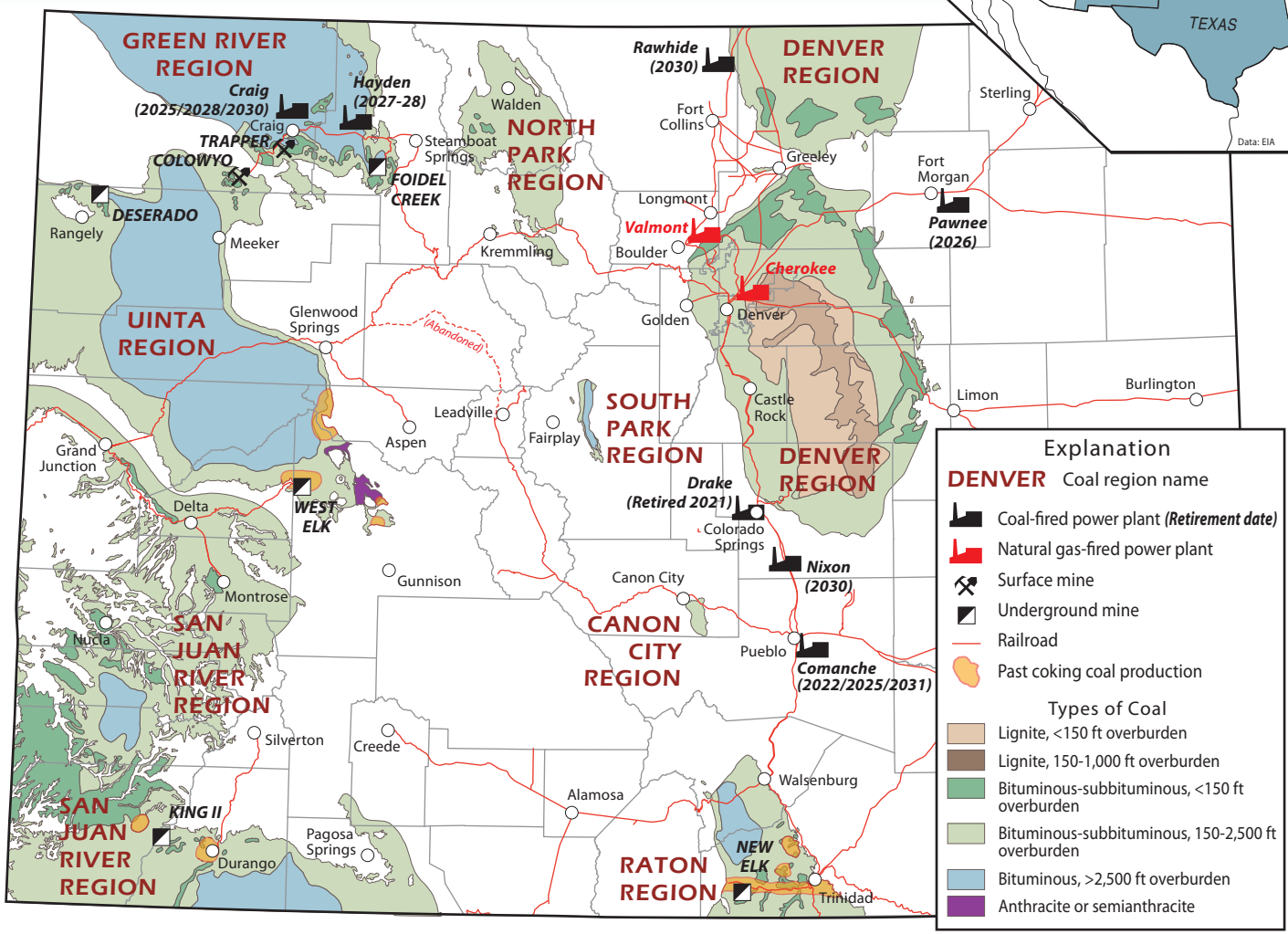
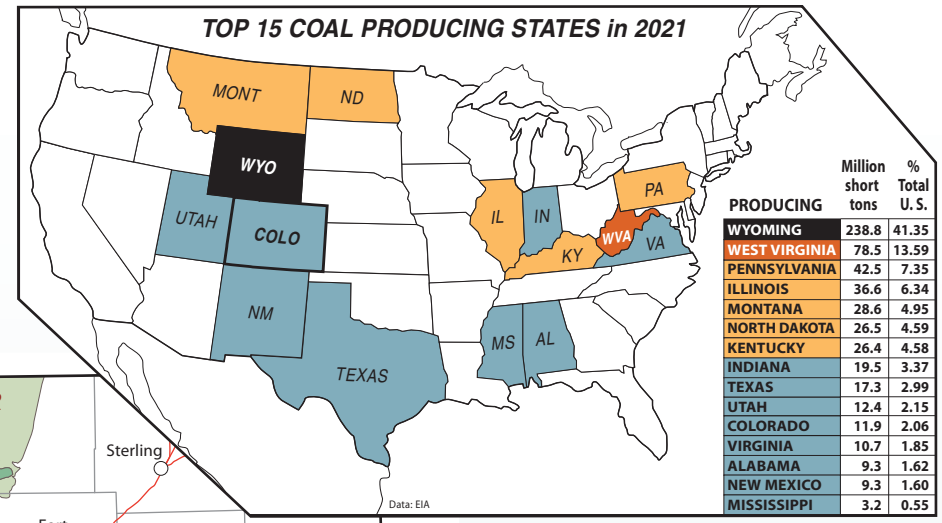


Figure 16. Locations of active coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2021. Dates in parenthesis are estimated retirement dates for coal-burning units.



PRODUCING	Million short tons	% Total U. S.
WYOMING	238.8	41.35
WEST VIRGINIA	78.5	13.59
PENNSYLVANIA	42.5	7.35
ILLINOIS	36.6	6.34
MONTANA	28.6	4.95
NORTH DAKOTA	26.5	4.59
KENTUCKY	26.4	4.58
INDIANA	19.5	3.37
TEXAS	17.3	2.99
UTAH	12.4	2.15
COLORADO	11.9	2.06
VIRGINIA	10.7	1.85
ALABAMA	9.3	1.62
NEW MEXICO	9.3	1.60
MISSISSIPPI	3.2	0.55

Figure 15. Top 15 coal-producing states in 2021.

Nuclear energy accounted for 18.9% of U.S. electricity production from utility scale facilities in 2021 (EIA, 2022i). At the end of 2021, there were 55 nuclear power plants with 93 nuclear reactors operating in 28 states (EIA, 2022j). Colorado is one of 22 states without an operating commercial nuclear power plant. Two new nuclear reactors are under construction in Georgia and are expected to come online between 2022 and 2023 (EIA, 2022k; Georgia Power, 2022). Currently, the average age of U.S. nuclear reactors is ~39 years old - the oldest operating reactor in the U.S. began commercial operation in December 1969 while the newest reactor came online in 2016 (the first reactor since 1996) (EIA, 2021b).

Figure 17 shows the average annual spot uranium prices in the U.S. since 2002. Prices have been generally trending downward since 2007 and after the 2011 Fukushima nuclear power plant accident in Japan. However, the average annual price increased in 2020 to $29.96 and $34.89 per pound in 2020 and 2021, respectively (Cameco, 2021).

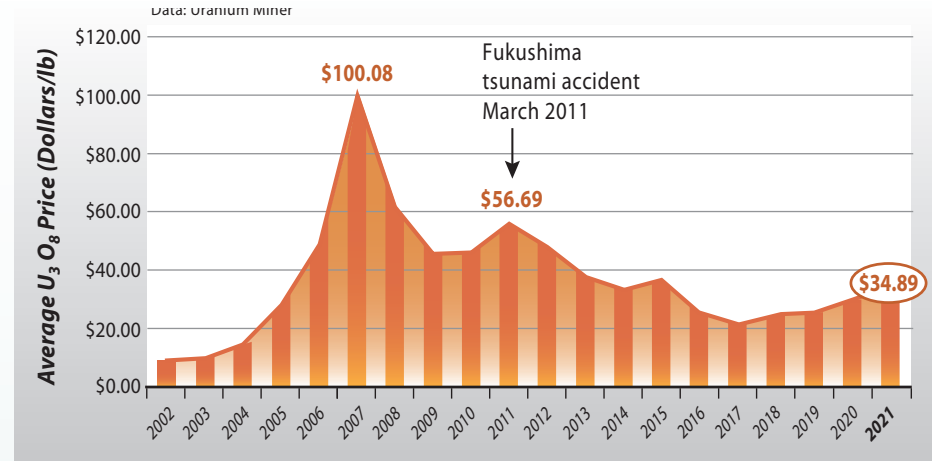


Figure 17. Average annual U_3O_8 price per pound in U. S., 2002–2021.

Figure 18 shows the estimated annual production of uranium concentrate in the U.S. between 1996 and 2021. Although Colorado has been a producer of uranium in the past, there are currently no producing uranium mines or mills in Colorado. Uranium concentrate production from U.S. mines in 2021 was the lowest recorded since 1949. In 2021, the U.S. produced 21,000 pounds of uranium concentrate from three in-situ leaching facilities (EIA, 2022l). Domestic uranium production for 2020 was unavailable (the EIA withdrew data to avoid disclosure of individual company data). However, 2021 production was down 88% from 2019 (EIA, 2022l). At the end of 2021: two Wyoming operations were operating with a combined capacity of 7.5 million pounds of uranium concentrate per year; nine in-situ recovery plants were on standby with a combined annual production capacity of 13.8 million pounds of uranium concentrate; and ten in-situ recovery plants were planned in New Mexico, South Dakota, Texas, and Wyoming with a combined annual production capacity of 15 million pounds of concentrate (EIA, 2022l).

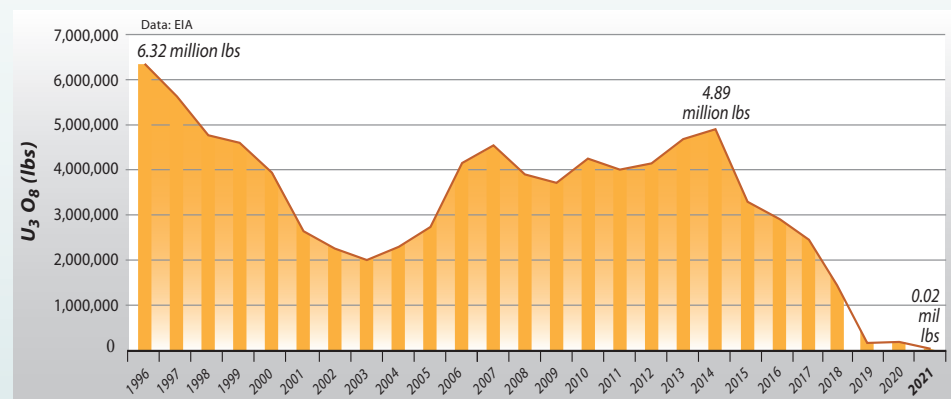


Figure 18. Annual production of uranium concentrate in U. S., 1996–2021.

In 2018, the U.S. Department of the Interior (DOI) listed uranium as a critical mineral. DOI defined a critical mineral as a non-fuel mineral or mineral material essential to the economic and national security of the U.S., the supply chain of which is vulnerable to disruption and, that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security (Fortier and others, 2018). However, in 2021, uranium was removed from the draft 2021 critical mineral list because *"the Energy Act of 2020 explicitly excluded fuel minerals from the definition of a critical mineral and the Mining and Mineral Policy Act of 1970 formally defined uranium as a mineral fuel, so uranium was not evaluated for inclusion on the 2021 draft list of critical minerals (Federal Register, 2021a)."* For more on critical minerals, see the "Critical Minerals" section of this report:

In 2021, most of the uranium delivered to U.S. civilian nuclear power reactors came from other countries including Kazakhstan (35%), Canada (14.8%) and Australia (14.4%) (EIA, 2022m). In 2022, U.S. President Joe Biden signed

the Inflation Reduction Act (IRA) which will attempt to lower energy bills and includes tax credits for existing nuclear reactors as well as providing tax incentives for clean energy technologies including advanced nuclear reactors. The IRA also provides $700 million to support the development of a domestic supply chain for high-assay low-enriched uranium (HALEU) which is needed to support advanced reactors (DOE, 2022). Also, the Appropriations Agreement for FY2022 was signed in March 2022 which provides $1.65 billion to the U.S. Department of Energy to develop the next generation of nuclear reactors, improve the safety and economic viability of current U.S. reactors, and contribute to the U.S. nuclear power industry (Schumer, 2022). Additionally, the DOE established the new Manufacturing and Energy Supply Chains Office in 2022 that (DOE, 2022b) *"will focus strengthening and securing energy supply chains needed to modernize the nation's energy infrastructure and support the clean energy transition. This office will engage with private-sector companies, other Federal agencies, and key stakeholders to collect, analyze, respond to, and share data about energy supply chains to inform future decision making and investment."*

NON-FUEL MINERAL RESOURCES

Non-fuel mineral resources include metals, industrial minerals, and construction materials (e.g., gold molybdenum concentrate, Portland cement, crushed rock, sand, and gravel). The total U.S. 2021 non-fuel mineral production value was estimated at $90.4 billion, a ~9.8% increase from last year's estimated total of $82.3 billion (USGS, 2022a). Colorado ranked 19th in U.S. non-fuel mineral production value and produced an estimated $1.61 billion, or ~1.78% of the estimated total U.S. production value (USGS, 2022a). **Figure 19** shows the estimated non-fuel mineral production value in Colorado over time.

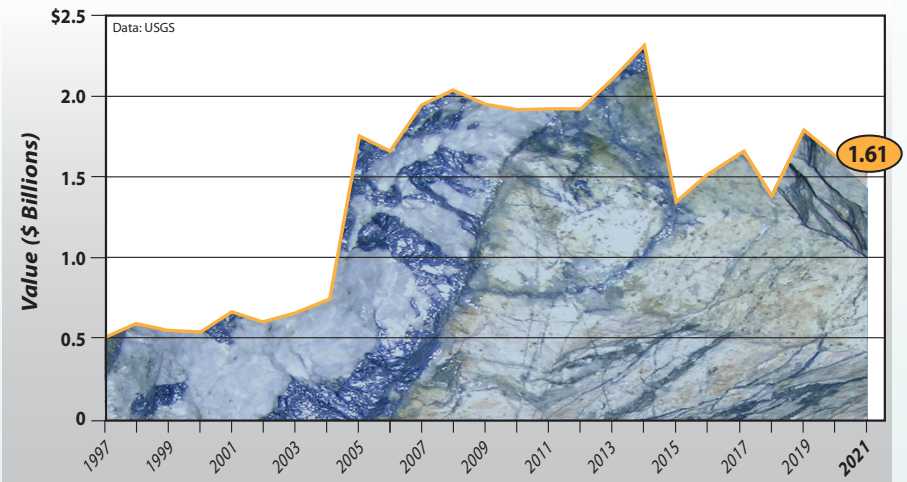


Figure 19. Total non-fuel mineral production value in Colorado, 1997–2021.

Metal Mining

Metals mined in Colorado include gold and molybdenum. The CGS estimates that the 2021 production value of gold and molybdenum in Colorado is ~$873 million. This is ~26.4% higher than the estimated value of these two commodities in 2020 of ~691 million mainly due to the higher production and price of molybdenum. Silver production in Colorado is a by-product of gold mining. Silver production values for Colorado were unavailable.

Molybdenum

In 2021, metallurgical applications used 88% of the total molybdenum consumed in the U.S. (USGS, 2022a). Molybdenum is typically used in the production of engineering steels, stainless steel, molybdenum metal and other alloys, and various chemicals. As of last year, the U.S. is the third largest producer of molybdenum in the world and produced an estimated 105.8 million pounds in 2021, valued at an estimated $1.728 billion, based on average prices reported by the USGS (USGS, 2022a). This is ~6% lower than the 2020 estimated production of 112 million pounds. China is the top producer (~287 million pounds in 2021) and Chile is the second largest producer (estimated 112 million pounds in 2021) (USGS, 2021a).

Colorado's annual production and the average annual price per pound for molybdenum trioxide (MoO_3) are shown in **Figure 20**. Estimated average prices decreased from $8.69 in 2020 to $15.92 per pound in 2021 (Freeport, 2022a). Most of the 2021 primary molybdenum production in the U.S. was from two Colorado mines that produced ~30 million pounds combined (Freeport, 2022a). In the U.S., Colorado ranked second in molybdenum production following molybdenum recovered as a by-product of copper mining at Arizona and Utah mines (**Figure 21**).

In Colorado, Freeport mines molybdenum at the Climax and Henderson mines. The Climax open pit mine is located northeast of Leadville, at Fremont Pass. As reported by Freeport, it includes a 25,000 metric ton per day mill with the ability to produce ~30 million pounds of molybdenum per year. The company reopened the mine in mid-2012 after a 17-year shutdown. Freeport reports that the Climax open pit mine produced 23 million pounds of molybdenum in 2015, 16 million pounds in 2016, 20 million pounds in 2017, 21 million pounds in 2018, 17 million pounds in 2019, 14 million pounds in 2020, and 18 million pounds in 2021. Due to declining molybdenum prices, Freeport reduced production at

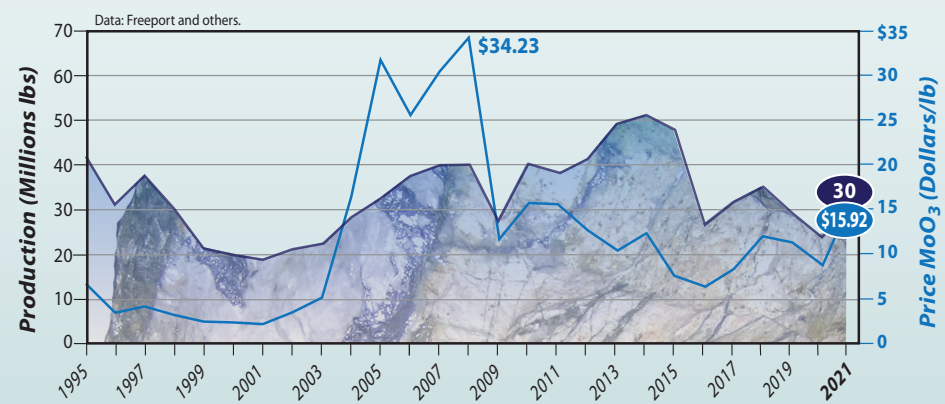


Figure 20. Molybdenum production in Colorado and average annual price 1995-2021.

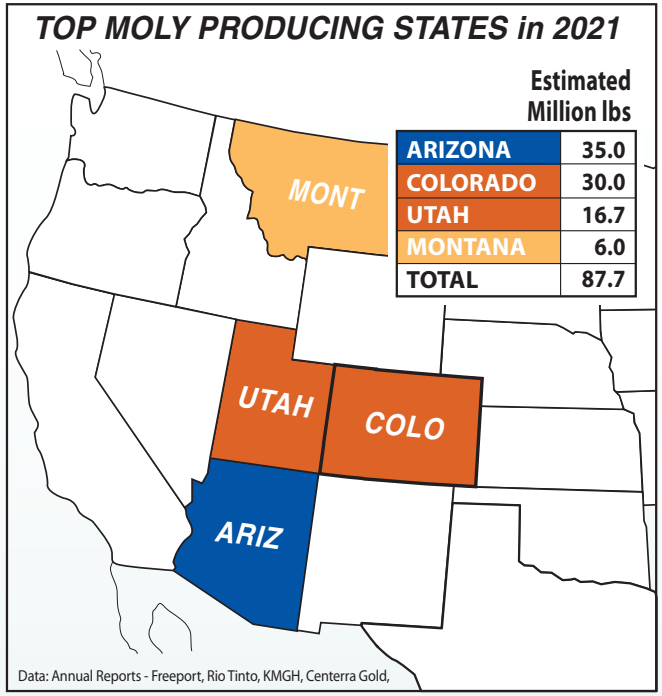


Figure 21. Top molybdenum producing states, 2021.

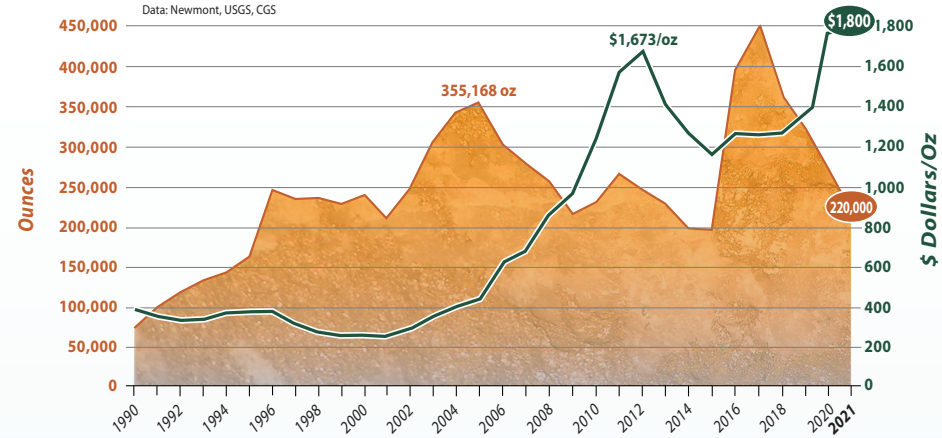


Figure 22. Colorado estimated gold production and average annual price per ounce, 1990–2021.

Climax in April 2020 but returned to normal production in the third quarter 2021 (Freeport, 2022a). In 2021, Freeport also reported that the Climax Mine had 138 million metric tons of proven reserves at an average grade of 0.15% molybdenum and probable reserves of 13 million metric tons at an average grade of 0.10% (Freeport, 2022a).

The Henderson Mine, located near Empire in Clear Creek County, has been in operation since 1976. Per Freeport, this operation is a large block-cave underground mine connected to a 32,000 metric tons per day concentrator in adjoining Grand County by a 15-mile-long conveyor. Freeport reported that the Henderson Mine produced 25 million pounds of molybdenum in 2015, 10 million pounds in 2016, 12 million pounds in 2017, 14 million pounds in 2018, 12 million pounds in 2019, 10 million pounds in 2020, and 12 million pounds in 2021. In 2021, Freeport also reported that the Henderson Mine had 37 million metric tons of proven reserves at an average grade of 0.18% molybdenum and probable reserves of 17 million metric tons at an average grade of 0.13% (Freeport, 2022a).

Gold and Silver

U.S. gold production decreased from 193 tons (6.2 million troy ounces) in 2020 to an estimated 180 tons (5.79 million troy ounces) in 2021 with an estimated value of $10.42 billion based on prices reported by the USGS (USGS, 2022a). In 2021, the U.S. was the fourth largest producer of gold in the world following China (370 tons), Australia (330 tons), and Russia (300 tons) (USGS, 2022a). **Figure 22** shows the price of gold and Colorado gold production from 1990 to 2021. In 2021, Colorado was the third largest producer of gold (220,000 ounces) in the U.S. (**Figure 23**)

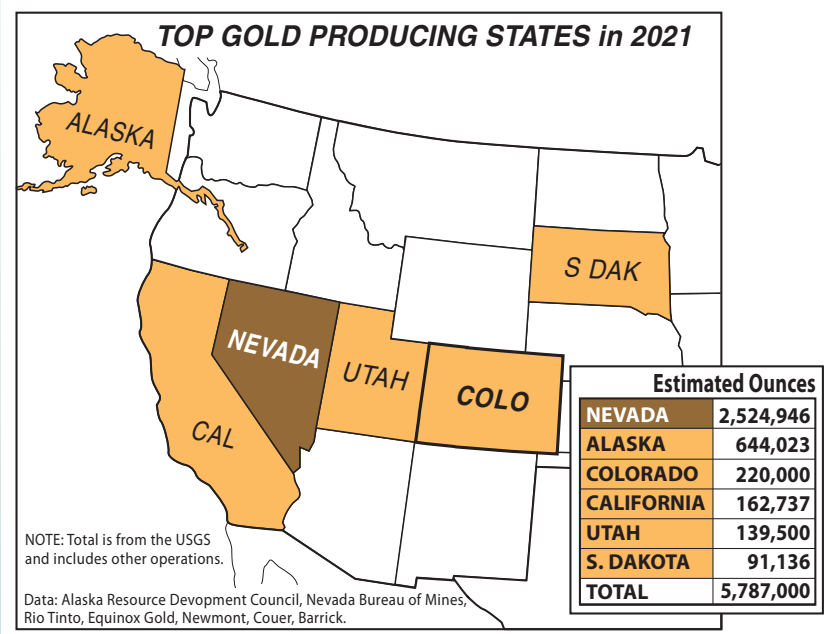


Figure 23. Major gold-producing states in 2021.

following Nevada (~2,524,946 ounces) and Alaska (~644,023 ounces). The average gold price increased in 2021 to $1,800 per ounce from $1,774 per ounce in 2020 (USGS, 2022a).

Gold production at Newmont Corporation's (Newmont) Cripple Creek and Victor (CC&V) open pit mine located in Teller County decreased from 272,000 ounces in 2020 to 220,000 ounces in 2021 (Newmont, 2022). CC&V also produces silver; however, the mine does not report production numbers for silver. In 2019, Newmont acquired Goldcorp Inc. and entered a joint venture with Barrick Gold in Nevada making it the largest gold mining company in the world now known as Newmont Goldcorp. Their corporate headquarters remain in Greenwood Village, Colorado. Newmont operates mines all over the world. In 2021, it was the largest producer of gold in the world (5.97 million ounces) (Kitco, 2022).

Sand and gravel aggregate operations recover a small amount of placer gold along some of Colorado's rivers and streams including the South Platte, Arkansas, and Colorado rivers, as well as Clear Creek. Additionally, a few small lode gold mines operated by private individuals or small groups also produce small tonnages of high-grade gold and silver ore. In 2021, one of the larger gold placer mines in Colorado was the Box Creek Placer Mine in Lake County (DRMS, 2022b). As of October 2022, there are currently 33 active mining permits with gold listed as the primary mined commodity in the Colorado Division of Reclamation, Mining and Safety (DRMS) database (DRMS, 2022a).

Other Exploration Activities and Mining Information

Worldwide exploration budget estimates for nonferrous metals increased ~35% from ~8.35 billion in 2020 to ~11.24 billion in 2021 (S&P, 2022). Most of this estimated total budget is for exploration targeting gold (55%), copper (21%), silver (6%), nickel (4%), lead/zinc (4%) and other commodities (11% - includes potash, phosphates, rare earth metals, molybdenum, and others) (S&P, 2022). Worldwide exploration budgets are forecasted to increase by 5 to 15% in 2022 (S&P, 2022).

Exploration and development projects that have undergone recent activities are discussed below. We compiled most of this information from company websites and available reports. Past CGS MEIA reports have additional information about these projects and updates associated with other properties including the Bates Hunter Mine, Golden Wonder Mine, Klondike Mine, May Day Mine, Ouray Silver Mine (Revenue-Virginius), San Juan Silver Project, and Tomichi porphyry deposit.

In October 2021, Bunker Hill Mining Corporation (Bunker Hill) announced its intention of entering a joint venture with MineWater Finance LLC (MineWater) to explore the mineral potential of the London Gold Mine and the London mining district (Bunker Hill, 2021). According to their website, MineWater LLC, partnered with MineWater, is the *"general contractor for the acquisition, cleanup and redevelopment of the London Mine...."* MineWater owns the mineral and surface rights and a portion of the economic rights in the water. The London Mine Group is located on both the north and south sides of London Mountain ~5 miles west of Alma, Colorado. It was discovered in 1873 and the bulk of the mining was conducted between 1875 and 1942 with intermittent production through 1989. The deposit is a structurally controlled polymetallic quartz vein deposit that historically produced several metals including gold, silver, lead, copper, and zinc (Scarbrough Jr., 2001).

Dateline Resources (Dateline) reported that they commenced ore mining and gold production from their Gold Links operation. In 2022, they are working on expanding the Lucky Strike mill and flotation to a 250 tons per day operation. Ore mined at Gold Links is processed at the Lucky Strike mill. Dateline reports that at the end of 2021, they commenced mining at Gold Links and they expect that development and exploration of the mine will be ongoing (Dateline, 2022). Dateline reported that vein material is currently being mined and stockpiled at the Lucky Strike Mill. The Gold Links Mine is in the Gold Brick mining district that historically produced gold, silver, lead, copper, and other metals. Between 1908 and 1912, the Gold Links Mine was reportedly the largest producer in the district mostly due to gold production. Mineralization occurs in veins hosted in Proterozoic-age metavolcanic and granitic rocks (Streufert, 1999).

Metallic Minerals Corp. (Metallic Minerals) released a National Instrument 43-101 technical report (technical report) in 2022 associated with the Allard Cu-Ag porphyry deposit at their La Plata project located in La Plata County. This report was released after announcing their final drill results from their 2021 exploration program which included 1,980 meters of drilling and additional sampling. The technical report (Metallic Minerals, 2022; page 9) states that, *"The underground Mineral Resource includes 115.7 million tonnes grading 0.39% copper equivalent (0.35% Cu and 4.02 g/t Ag) in the Inferred category, at a base case cut-off grade of 0.25% CuEq."* The technical report also indicates that Metallic Minerals proposes to conduct additional drilling and surveys of the property in 2022 (Metallic Minerals, 2022). During the Late Cretaceous-early Tertiary igneous rocks in this area intruded into older sedimentary rocks. Spanish explorers reportedly observed operating mines in the La Plata Mountains in the 18th century. More recent historic mining in the area started around 1873 but most of the production appears to be from the early 1900s to at least the late-1930s and included gold, silver, copper, and lead (Eckel and others, 1949).

Viscount Mining Corp. (Viscount) completed additional drilling in 2021 and 2022 at their property located within the historic Hardscrabble mining district near Silver Cliff, Colorado. Silver mineralization occurs in a rhyolite tuff deposited ~35.4 to 32 million years ago from the Silver Cliff caldera (McIntosh and Chapin, 2004). According to Viscount, historic and new drilling results will be included in an updated report to be released later in 2022 (Viscount, 2022a).

Also, Viscount completed a geophysical survey at their Passiflora target in 2022. Results of the geophysical survey reportedly detected a (Viscount, 2022b) *"....zone of extremely low resistivity in the Silver Cliff caldera. The main anomaly is bowl-shaped and at a depth of ~450 meters (~1475 feet) at a point nearest to the surface..... The 2D and 3D modeling depth of the anomaly extends ~1,500 meters (~4920 feet) deep...but the source could be deeper."* Viscount reports that this anomaly could indicate the presence of a porphyry at depth (Viscount, 2022b). For more on the Hardscrabble and other historic metal mining districts in the state, see the CGS's historic metal mining district online map and data located here: https://coloradogeologicalsurvey.org/publications/historic-metal-mining-districts-colorado-map/.

Critical Minerals

The 2017 President Trump issued Executive Order (E.O.) No. 13817 entitled "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," ordered the creation of a critical minerals list. A critical mineral, as identified by the Secretary of the Interior (S.I.) in coordination with other federal agencies, was defined as a non-fuel mineral or mineral material essential to the economic and national security of the U.S., the supply chain of which is vulnerable to disruption and, that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security. The USGS, in coordination with the U.S. Bureau of Land Management (BLM), provided the draft critical mineral list, as documented in Fortier and others (2018). The critical minerals listed include (in alphabetical order): aluminum (bauxite), antimony, arsenic, barite, beryllium, bismuth, cesium, chromium, cobalt, fluorspar, gallium, germanium, graphite (natural), hafnium, helium, indium, lithium, magnesium, manganese, niobium, platinum group metals, potash, the rare earth element (REE) group, rhenium, rubidium, scandium, strontium, tantalum, tellurium, tin, titanium, tungsten, uranium, vanadium, and zirconium.

In 2021, the USGS modified the original draft critical mineral list and (Federal Register, 2021; Nassar and Fortier, 2021) added zinc, nickel, specific platinum group elements (ruthenium, rhodium, palladium, iridium, and platinum) and the specific REEs (cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, samarium, terbium, thulium, ytterbium, and yttrium). Also, the following minerals were deleted from the list: helium, potash, rhenium, strontium, and uranium (Federal Register, 2021). The USGS is seeking comments on the critical minerals and methodology associated with the new list (Federal Register, 2021; Nassar and Fortier, 2021). Several current actions by U.S. lawmakers promoting the domestic production of critical minerals in the U.S. are presented in the Federal Mining Law Reform section of this report.

Minerals containing almost all the elements provided in the critical mineral list occur in Colorado. However, many of these may not occur in sufficient quantities to mine economically. Colorado is a known producer or past producer of many of the minerals/mineral materials provided in the critical minerals list especially (in no particular order) zinc, tungsten, fluorspar, and vanadium. Also, Colorado contains deposits of titanium, niobium, REE, and potentially lithium, as well as other critical minerals that may be economical to extract. For more on critical minerals in Colorado, see the CGS website:

https://coloradogeologicalsurvey.org/minerals/strategic-critical/.

The CGS is currently working with the USGS to determine areas that may contain potential resources of critical minerals in Colorado. Between 2019 and 2022, the USGS hosted four critical mineral workshops that include mineral geologists from the USGS and from state geological surveys across the U.S. These workshops consist of regional teams that determine critical mineral focus areas, or areas where critical minerals are likely to be deposited, using a mineral system approach (Hofstra and Kreiner, 2020). During these workshops, participants select priority areas for future geological mapping and other geological investigations related to critical minerals. The latest version of the critical mineral focus areas was recently published by the U.S. Geological Survey (Dicken and others, 2022) and is available here: https://doi.org/10.5066/P9DIZ9N8. An online interactive map with the focus areas for the U.S. is available here: https://mrdata.usgs.gov/earthmri/focus-areas/.

Priority areas are selected for future geological mapping and other geological investigations related to critical minerals. Geological mapping projects associated with these priority areas are funded through the USGS Earth Mapping Resources Initiative (EarthMRI) with matching funds from state surveys. The CGS is currently working on two geological mapping projects and one sampling program associated with EarthMRI as discussed below. For more on the U.S. Geological Survey EarthMRI program, see the EarthMRI home page: https://www.usgs.gov/special-topics/earth-mri. Also, the USGS EarthMRI acquisitions interactive map viewer provides an overview of current projects in the U.S.: https://ngmdb.usgs.gov/emri/#3/40/-96.

The La Plata EarthMRI project involves geological mapping of four quadrangles at 1:24,000-scale located in and around the La Plata Mountains (La Plata/Montezuma counties) as well as geochemical sampling to better define rock types and potential mineralization. The La Plata Mountains area contains the La Plata polymetallic critical mineral focus area that includes mineralization associated with Late Cretaceous to Paleogene alkaline intrusions that caused structural doming of the region. This dome has eroded exposing mineralized intrusive and sedimentary rocks within the project area. For more on the geology and ore deposits associated with the La Plata mining district see Cappa (1998) and Eckel, (1949).

The Wet Mountains EarthMRI project (Custer and Fremont counties) includes compilation geological mapping using previously published information as well as new geological mapping to support the recent high resolution geophysical survey (airborne geomagnetic and georadiometric) conducted by the USGS. The field area includes a portion of the Wet Mountains and an area to the west. Additionally, geochemical samples have been collected from mineralized areas to determine, and in some cases confirm, the concentrations of critical minerals in this area. An area west of the Wet Mountains contains mineralized dikes and veins containing critical minerals and are associated with three main alkaline Cambrian intrusions. For more on the geology and ore deposits associated with this region see Armbrustmacher (1984 and 1988), Cappa (1998), and O'Keeffe and others (2021).

The critical minerals in mine-related waste EarthMRI project involves sampling of tailing and/or waste piles associated with historic mining areas in Colorado that may contain critical minerals. Several areas will be sampled which tentatively include the following mining districts: Idaho Springs (Clear Creek County), La Plata (La Plata/Montezuma counites), Bonita Peak (San Juan County), Rosita/Querida (Custer County), and Montezuma (Summit County). Seasonal water sampling is also being conducted at several perpetual mine effluent locations in areas known to host critical minerals including the Eagle Mine (Eagle County), Leadville Mine Drainage Tunnel (Lake County), Nelson Tunnel (Mineral County), St. Louis Tunnel (Dolores County), Argo Tunnel (Clear Creek County), and other locations. See the CGS's historic metal mining districts interactive map for more on these areas:

https://coloradogeologicalsurvey.org/publications/historic-metal-mining-districts-colorado-map/

In addition to projects associated with the USGS EarthMRI program, the CGS is a team member on two carbon ore, rare earth and critical minerals (CORE-CM) grants from the Department of Energy in the Greater Green River (University of Wyoming, 2022) and Uinta coal regions (UAMMI, 2022) located in northwestern and western Colorado, respectively. These projects involve sampling and analysis of coal and coal-related samples that may contain elevated concentrations of rare earth elements and other critical minerals.

Federal Mining Law Reform

Within the last few years, there has been several actions by federal lawmakers to support the domestic production of critical minerals including executive orders to secure U.S. supply chains (U.S. White House, 2021a and 2021b), bills supporting tax credits for domestic production of rare earth magnets (Congress, 2021), and authorization of the use of the Defense Production Act (U.S. White House, 2022) to support the production of critical minerals (lithium, cobalt, graphite, nickel, and manganese) to support the production of large scale batteries. Additionally, the Bipartisan Infrastructure Law (BIL) (U.S. White House, 2021c) requires the Department and the U.S. Department of Agriculture to submit a report to Congress identifying legislative and regulatory recommendations to increase timeliness of permitting activities for exploration and development of domestic critical minerals:

To meet some of these actions, the U.S. Department of the Interior announced the launch of a new interagency working group, comprised of experts in mine permitting and environmental law from across the Federal government, to review existing mining laws, regulations, and the permitting processes (DOI, 2022a). According to the DOI, the group will inform potential rulemaking efforts on mining, and will help support President Biden's vision for a whole-of-government effort to promote the sustainable and responsible domestic production of critical minerals (DOI, 2022b). These efforts will likely assist with promoting hardrock leasing, mining, and reclamation as proposed in the past (e.g., see S. 1396 and H.R. 2579, Congress, 2019 and 2020, respectively, and the summary provided in O'Keeffe, 2022).

Updated Federal Mineral and Land Records System

The BLM continues to work on its new Mineral and Land Records System (MLRS) which will replace their Legacy Rehost 2000 (LR2000) case management and land status records system (BLM, 2022). They are working on using a phased approach to transition mining claims, fluid minerals and geothermal, and other case types over the next few years. According to the BLM's website (BLM, 2022), "MLRS is a customer-centric, geospatially enabled land information system that employs nationally standardized business processes, ensuring the quality and accuracy of land and mineral records and data while securely delivering land records information to relevant BLM staff, customers, and the public. "MLRS *is currently available for mining claims, oil and gas, and geothermal cases. Over the next two years, additional MLRS modules will be released in support of land use authorizations and realty billing; coal and other mineral development; land and mineral title; and withdrawals, classifications, and other actions on Federal lands and mineral estate.*"

Sand, Gravel, and Crushed Stone

In 2021, the ~1.0 billion tons of construction sand and gravel produced domestically was used primarily for Portland cement concrete aggregates (~46%), road base/coverings/road stabilization (~21%), construction fill (13%), and asphalt/other bituminous mixtures (~12%) (USGS, 2021a). Other uses include filtration, golf course maintenance, plaster and gunite sands, railroad ballast, roofing granules and snow and ice control (USGS, 2022a). In 2021, crushed stone produced domestically was used primarily for construction aggregate (72%) (especially for road construction and maintenance), cement manufacturing (16%), lime manufacturing (8%), agricultural uses (2%), and for other uses (USGS, 2022a). Seventy percent of the 1.5 billion tons of crushed stone produced domestically in 2021 was limestone and dolomite (USGS, 2022a). DRMS currently lists over 830 active permits for sand, gravel, aggregate, and aggregate-related quarries in Colorado (DRMS, 2022a).

Colorado quarry operators produced 58.64 million short tons of aggregate (sand, gravel, and crushed stone) in 2021 (USGS, 2022c) (**Figure 24**). Colorado was the sixth leading producer of construction sand and gravel in the U.S. (USGS, 2022c) and the estimated 2021 production value was $346 million for sand and gravel and $184 million for crushed stone. Average prices and production for sand and gravel and crushed stone are shown in **Figure 25 and Figure 26**, respectively.

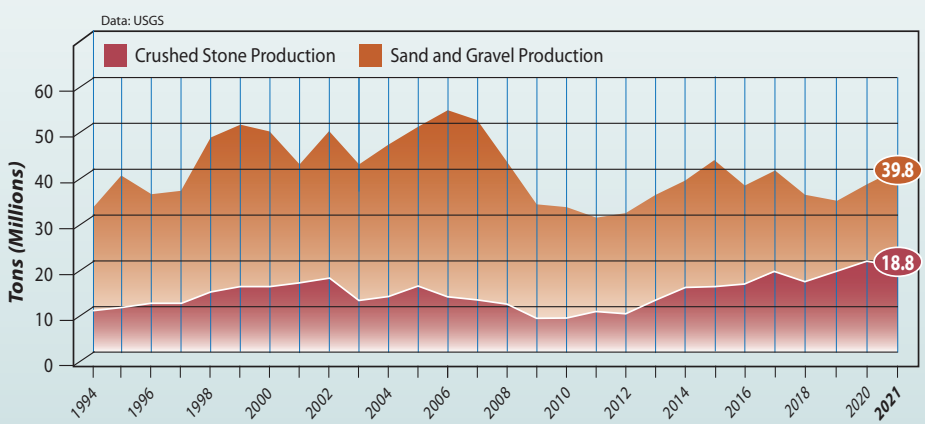


Figure 24. Aggregate production in Colorado, 1994–2021.

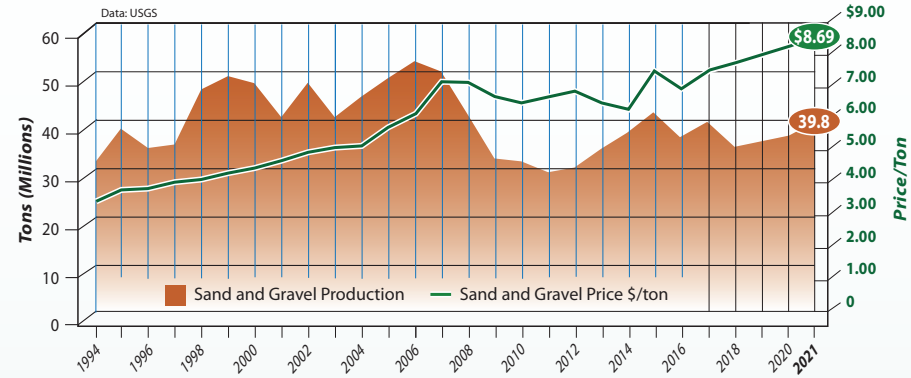


Figure 25. Price and production of sand and gravel aggregate in Colorado, 1994–2021 (sold or used by producers in the U.S.).

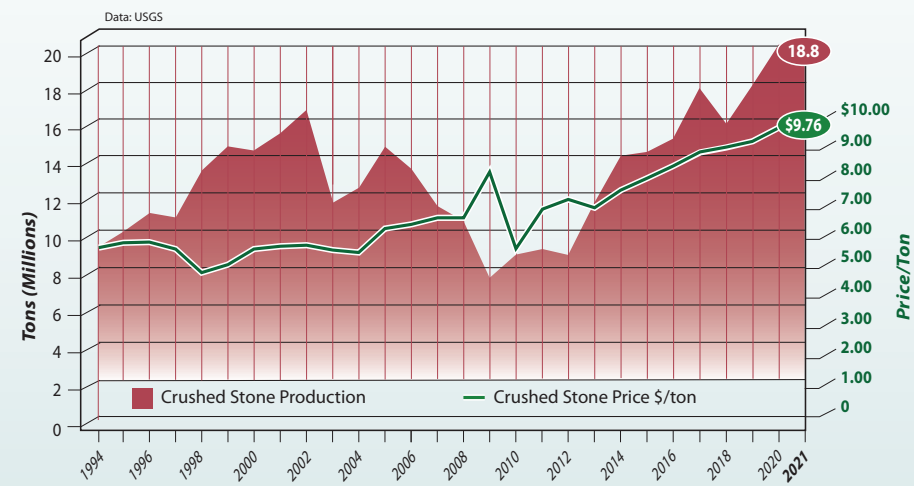


Figure 26. Price and production of crushed stone aggregate in Colorado, 1994–2021 (sold or used by producers in the U.S.).

Colorado uses a large amount of aggregate to build and maintain infrastructure. The cost of aggregate to the user is highly dependent on aggregate transportation costs. Locating quarries close to population centers helps lower overall costs. However, residential and commercial development near an aggregate source can make permitting a new or expanding quarry a challenge. To help local governments identify potential sources of sand, gravel and quarry aggregates,

the CGS published maps of sand, gravel, and quarry aggregate resources for Colorado Front Range counties which are available for download on our website (Schwochow and others, 1974). These maps are also available in a CGS online interactive map and the GIS files can be downloaded at the following locations, respectively (copy/paste links to browser):

https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html ?id=003cf86ff0e6440989b1496e368c115e

https://coloradogeologicalsurvey.org/publications/atlas-sand-gravel-quarry-aggregate-resources-colorado-front-range/

Bipartisan Infrastructure Law (BIL)

The demand for aggregates will likely increase in Colorado to assist with building infrastructure. In November 2021, the U.S. Congress (Congress) passed the BIL (Infrastructure Investment and Jobs Act) which includes provisions to rebuild U.S. roads, bridges, and rails (U.S. White House, 2021c). As summarized last year (O'Keeffe, 2022), the U.S. Department of Transportation provides a summary of what Colorado can expect here (DOT, 2022):

https://www.transportation.gov/briefing-room/bipartisan-infrastructure-law-will-deliver-colorado

As of November 2022, over $1.1 billion has been provided (Hickenlooper, 2022) with a total of $3.0 billion of funding announced for Colorado. The announced BIL project locations are available on this interactive online map (GSA, 2022):

https://d2d.gsa.gov/report/bipartisan-infrastructure-law-bil-maps-dashboard

A summary of some of the projects is available at this website (Hickenlooper, 2022):

https://www.hickenlooper.senate.gov/press_releases/one-year-into-bipartisan-infrastructure-law-hickenlooper-lauds-3-billion-announced-for-colorado-so-far/

Cement

Portland cement in Colorado is used primarily in the production of concrete. Concrete consists of a mixture of aggregates (e.g., sand, gravel, or crushed stone) mixed with water and cement. Concrete contains between about 60 and 75% coarse and/or fine aggregate (PCA, 2022). A common way to create Portland cement is by heating lime, clay, silica, alumina, iron, and other materials at high temperatures in a cement kiln which creates small round pellets (called "clinkers") that are ground, mixed with limestone and gypsum, and used to make concrete. Several Portland cement plants operated in Colorado during 2021 including: LafargeHolcim (US), Inc. (LafargeHolcim) in Florence, the GCC of America plant in Pueblo, and CEMEX plant near Lyons. All three mining companies are currently mining the Niobrara Formation as feed stock for their cement products. The Upper Cretaceous Niobrara Formation was deposited during a major marine transgression of the Western Interior Seaway around 82 to 89.5 million years ago (Sonnenberg, 2016). It is also a major source of oil and gas, especially in the Front Range just northeast of Denver. Like the aggregate business, the production of cement is largely tied to the construction industry. Estimated Portland cement production (e.g., shipments from Colorado) in 2021 was 2.6 million tons (USGS, 2022d). Production and average cement prices are shown on **Figure 27**.

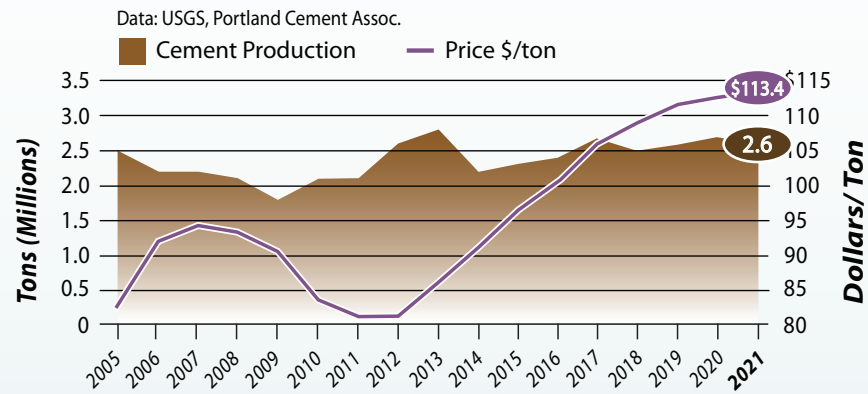


Figure 27. Price and production of cement in Colorado, 2005–2021.

LafargeHolcim plant in Fremont County (photo by Larry Scott).

Clay and Shale

Clay is mined primarily in eastern Colorado along the Front Range and is used mostly to make brick and tile. Clay has been mined from the Laramie Formation, Dawson Arkose, and Denver Formation as well as the Dakota Group. DRMS records indicate that there are 40 active permits for clay and 4 for shale in Colorado (DRMS, 2022a). Two brick companies currently operate in the Denver area: the old Robinson Brick Co., owned by General Shale/Wienerberger, and Summit Brick Co. The Summit Brick Co. also operates a clay brick manufacturing facility in Pueblo (Summit Brick Company, 2022). Common clay and shale production in Colorado was estimated at 297,000 short tons in 2017 and 293,000 tons in 2018 (USGS, 2022e). The estimated average price of common clay was ~$16.00 per ton in 2021 (USGS, 2022a). Colorado clay production estimates were unavailable for the last three years.

Arcosa Lightweight (Arcosa) produces lightweight aggregate in Jefferson County from shale. They quarry Cretaceous Pierre Shale near their production facility which is then heated in a high temperature kiln at temperatures over 2,000 degrees Fahrenheit where it expands and hardens. This creates a ceramic lightweight aggregate, with a lower bulk density of natural aggregates, and is used in asphalt surface treatments, structural lightweight concrete, concrete masonry, geotechnical fill, and other applications (Arcosa, 2022).

Gypsum

Gypsum mined in Colorado is used to produce wallboard, as an ingredient in cement production, a soil conditioner, and for other industrial uses. In 2018, Colorado was one of the top six states in the U.S. that accounted for 67% of the total gypsum mine output (USGS, 2019). Crude gypsum 2021 production in the U.S. is 23 million tons (USGS, 2022a). Information on gypsum produced in Colorado is unavailable for proprietary reasons. There are currently 8 active mine permits associated with gypsum in Colorado (DRMS, 2022a).

American Gypsum Co. operates a large quarry and fabrication plant for wallboard in Eagle County, near the town of Gypsum, and is the fifth largest producer of gypsum wallboard in North America (American Gypsum, 2022). In this area, gypsum (hydrated calcium sulfate) occurs in the Pennsylvanian Eagle Valley Evaporite which is composed of both gypsum and anhydrite (calcium sulfate) as well as halite (salt). These evaporite minerals were reportedly deposited in a landlocked marine trough where marine circulation and interchange was limited (Mallory, 1971). Near Eagle, Colorado, the evaporite interval can be 9,000 feet thick (Mallory, 1971). In 2020, the BLM approved a 99.2-acre expansion of American Gypsum's mine in Eagle County following a public comment period. As part of their final permitting efforts, American Gypsum obtained a county special use permit in 2021 for the expansion (Vail Daily, 2021). Currently, the mine and plant produce ~600 million square feet of drywall per year and the expansion adds 25 years of reserves (Vail Daily, 2021). Pete Lien & Sons mines gypsum for the cement industry and soil amendment from the Munroe Quarry north of Fort Collins in Larimer County (Lien, 2021). Gypsum is also mined in Fremont County.

Sodium Bicarbonate (Nahcolite)

Sodium bicarbonate (more commonly known as baking soda) is primarily used in food preparation and baking, personal care products, pharmaceuticals, animal feed products, pool and water treatment, and other applications. Natural Soda, LLC. (Natural Soda), operates a nahcolite solution mine in Rio Blanco County. Natural Soda was previously owned by Rincon Ltd., but was acquired by Huber Engineered Materials (based in Atlanta, Georgia) in late 2021 (HEM, 2022). Nahcolite is the naturally occurring mineral of sodium bicarbonate ($NaHCO_3$). High grade nahcolite (greater than 80%) is recovered from the Parachute Creek Member of the Eocene Green River Formation in the Piceance Basin. The Green River Formation was deposited in an ancient lake, known as Lake Gosiute, which occupied this area from between ~52.5 to 47.5 million years ago (Smith and others, 2008). Nahcolite is present in the oil shale deposits where it occurs as disseminated aggregates, nodules, bedded units of disseminated brown crystals, and white crystalline beds associated with other minerals (e.g., dawsonite and halite) (USGS, 2009). Mine operators pump hot water down a well ~1,900 feet deep to dissolve the nahcolite. Other wells recover the sodium bicarbonate-enriched solution and pump it to the surface where the solution cools and precipitates sodium bicarbonate which is further dried and prepared to produce commercial grade product (Hardy and others, 2003; Brownfield and others, 2010).

The USGS estimated that the Parachute Creek Member of the Eocene Green River Formation in the Piceance Basin, Rio Blanco County, contains an estimated in-place resource of over 43 billion short tons of nahcolite over ~170,000 acres (USGS, 2009). Natural Soda completed an expansion project in 2013 to double the mine's production capacity to 250,000 tons per year. Production in 2018, 2019, 2020, and 2021 was 188,000; 231,562; 238,266; and 257,000 tons, respectively (**Figure 28**) (written communication, Natural Soda, 2022).

Dimension and Decorative Stone

Dimension stone is any visually appealing rock that is quarried, cut, or shaped into useful forms. Colorado has many dimension stone and decorative stone producers who quarry sandstone, granite, marble, rhyolite, and alabaster (a form of gypsum) for use as dimension stone. Dimension stone is used to construct buildings, wall cladding or veneer, monuments, floor tiles, walkways (flagstone), landscaping features, and sculptures. Decorative stone is any type of rock that

is used in its natural form for aesthetic purposes. In Colorado, various types of rock are mined locally for decorative use. **Figure 29** shows Colorado dimension stone production for the period from 2005 to 2019. In 2018 and 2019, Colorado produced ~31,420 and 24,030 short tons of dimension stone with an estimated production value of $6.3 million and $11.7 million, respectively (USGS, 2022a). Colorado dimension stone 2020 and 2021 production data were not available. In 2021, Texas, Wisconsin, Indiana, Georgia, and Vermont accounted for ~67% of U.S. production (USGS, 2022a). The rock types sold in the U.S. in 2021 by descending value included limestone (47%), granite (28%), sandstone (11%), slate (7%), dolomite (4%), and other miscellaneous stones (7%) (USGS, 2022a).

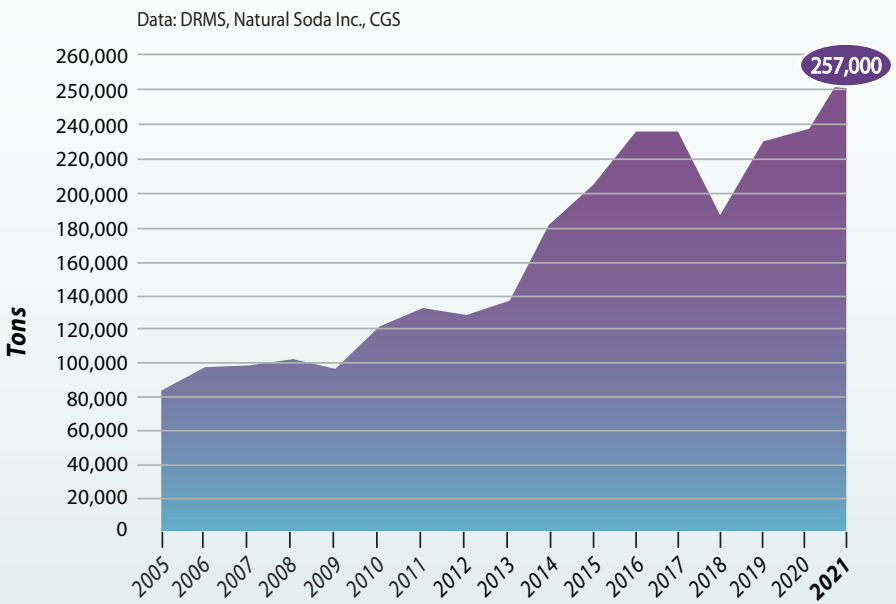


Figure 28. Estimated production of nahcolite in Colorado, 2005–2021.

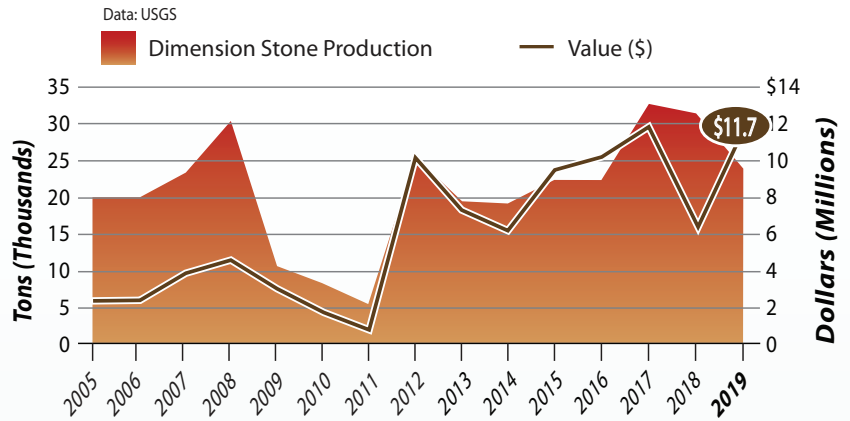


Figure 29. Production and product value of dimension stone in Colorado, 2005–2019.

INDUSTRIAL GASES (NON ENERGY)

Carbon Dioxide

Naturally occurring carbon dioxide gas (CO_2) was produced in 2021 primarily from three areas in Colorado (in order of decreasing production volume): McElmo Dome in Montezuma County, Doe Canyon Deep in Dolores County, Sheep Mountain Field in Huerfano County, and the Rangley Field in Rio Blanco County (COGCC, 2022a). McCallum Field in Jackson County has also produced CO_2 in the past. Kinder Morgan's McElmo Dome and the Doe Canyon Deep units are the largest producers in Colorado. About 93% of the 2021 production of CO_2 in Colorado was from Montezuma County (COGCC, 2022a). CO_2 is produced from wells in a similar way to natural gas production. Oil producers mainly use CO_2 in enhanced oil recovery (EOR) in Texas and New Mexico. EOR is implementing various techniques for increasing the extraction of crude oil from an oil field. EOR is also called improved oil recovery or tertiary recovery (as opposed to primary and secondary recovery). CO_2 is used to extend the life of a well after the initial pressure in the well decreases. Other uses for CO_2 include welding gases, manufacture of dry ice, and in the food and beverage industry. In 2021, Colorado produced an estimated 279 billion cubic feet (Bcf) at an estimated average price of $1.06 per thousand cubic feet (Mcf) for an estimated value of $296 million (COGCC, 2022a). **Figure 30** shows Colorado's estimated CO_2 production for the period 1994-2021.

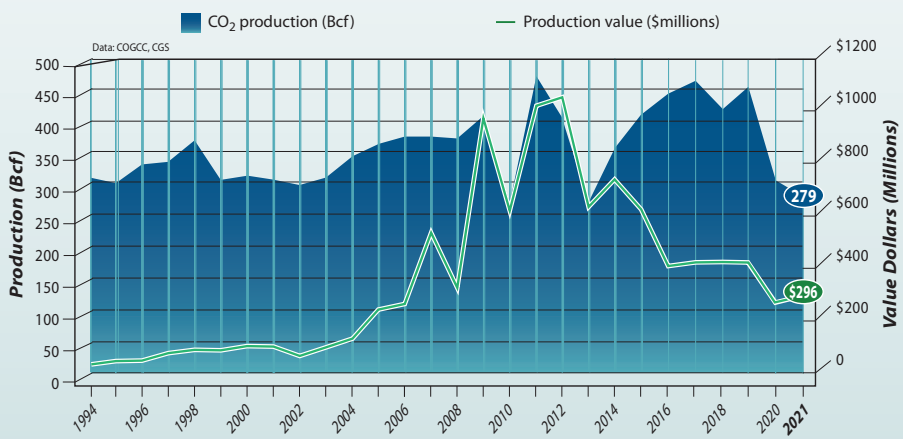


Figure 30. CO_2 production and estimated production value in Colorado, 1994–2021.

Helium

In 2021, helium was primarily used for magnetic resonance imaging, lifting gas (e.g., for lifting high-altitude equipment), analytical and laboratory applications, electronics and semiconductor manufacturing, welding, and other applications including engineering/scientific applications (USGS, 2022a). As it was in 2020, the price for private industry grade-A helium in 2021 was ~$210 per Mcf (USGS, 2022a). The BLM has managed the Federal Helium System under the Helium Stewardship Act of 2013. In September 2021, the BLM completed sales of the remaining Federal helium inventory and transferred remaining assets to the General Services Administration. Helium will be available to federal customers until the summer 2022 (USGS, 2022a).

The USGS estimates that the Rocky Mountain region of the U.S., which includes most of Colorado, contains ~148 Bcf of recoverable helium resources from known natural gas reservoirs (Brennan and others, 2021). The southeastern Colorado Ladder Creek gas plant facility located in Cheyenne Wells, Cheyenne County, produces Grade-A helium. In late 2019, Tumbleweed Midstream LLC (Tumbleweed) purchased the facility from DCP Midstream LLC. In early 2021, Tumbleweed announced a new 10-year sales agreement with a global helium supplier and plans to initiate a plant expansion later in 2021. The Ladder Creek gathering system includes ~730 miles of pipeline and the plant has a current processing capacity of 38 million cubic feet (MMcf) per day which could be expanded to 57 MMcf per day (Tumbleweed, 2022).

In 2015, Air Products and Chemicals, Inc. (Air Products) built a helium production facility in Doe Canyon. They extract most of the helium from a gas stream composed primarily of carbon dioxide. The plant has a capacity of ~230 MMcf per year and 2019 production is reportedly ~140 MMcf per year (Edison, 2021). As reported last year (O'Keeffe, 2022), Blue Star Helium Ltd. (Blue Star) continues to explore for helium in Las Animas County. In 2022, Blue Star reported that they successfully recovered helium from three exploratory wells at their Galactica/Pegasus prospects. They indicate that helium concentrations of up to 3.14% were reported in gas columns in the Permian Lyons Sandstone. Other exploration wells identified potential helium zones in these rocks. They are performing helium well permitting activities and exploration at several prospects in the area (Blue Star, 2022). More information is available on their website.

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Disclaimer

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References

American Gypsum, 2022, accessed December 2022, https://www.americangypsum.com/our-company.

Arcosa Lightweight (Arcosa), 2022, accessed December 2022, https://arcosalightweight.com/about.

Armbrustmacher, T.J., 1984, Alkalic rock complexes in the Wet Mountains Area, Fremont and Custer counties, Colorado: U.S. Geological Survey Professional Paper 1269, 33 p., https://pubs.er.usgs.gov/publication/pp1269.

Armbrustmacher, T.J., 1988, Geology and resources of thorium and associated elements in the Wet Mountains area, Fremont and Custer

BLM (U.S. Bureau of Land Management), 2022, Mineral and land records system (MLRS), https://www.blm.gov/services/land-records/mlrs.

Blue Star Helium Ltd. (Blue Star), 2022, Half year report, for the half year ended 30 June 2022: Blue Star Helium Limited and Controlled Entities, 24 p., https://www.bluestarhelium.com/investor-centre/asx-announcements/?pdf_year=2022.

Brennan, S.T., Rivera, J.L., Varela, B.A., and Park, A.J., 2021, National assessment of helium resources within known natural gas reservoirs: U.S. Geological Survey Scientific Investigations Report 2021-5085, 5 p., https://pubs.er.usgs.gov/publication/sir20215085.

Brownfield, M.E., Mercier, T.J., Johnson, R.C., and Self, J.G., 2010, Nahcolite resources in the Green River Formation, Piceance Basin, Colorado: U.S. Geological Survey Digital Data Series DDS–69–Y, chapter 2, 51 p., https://pubs.usgs.gov/dds/dds-069/dds-069-y/REPORTS/69_Y_CH_2.pdf.

Bunker Hill Mining Corporation, 2021, Bunker Hill announces exploration JV with Minewater on London mining gold district in Colorado: accessed December 2022, https://bunkerhillmining.com/news-and-media/news-releases/bunker-hill-announces-exploration-jv-with-minewater-on-london-mining-gold-district-in-colorado.

Cameco, 2021, Uranium price: Cameco, accessed December 2021, https://www.cameco.com/invest/markets/uranium-price.

Cappa, J.A., 1998, Alkalic igneous rocks of Colorado and their associated ore deposits: Colorado Geological Survey Resource Series 35, 138 p., https://coloradogeologicalsurvey.org/publications/alkalic-igneous-rocks-associated-ore-deposits-colorado/.

Carroll, C.J., 2004, 2003 Summary of coal resources in Colorado: Colorado Geological Survey Special Publication 54, 25 p., https://coloradogeologicalsurvey.org/publications/summary-coal-resources-colorado-2003/.

COGCC (Colorado Oil and Gas Conservation Commission), 2022a, Colorado oil and gas commission data downloads: Colorado Oil and Gas Conservation Commission, accessed October 2022, https://cogcc.state.co.us/data2.html#/downloads.

COGCC, 2022b, Colorado oil and gas information system: Colorado Oil and Gas Conservation Commission, Department of Natural Resources, accessed October 2022, https://cogcc.state.co.us/data5_ext.html#/cogis.

COGCC, 2022c, 2021 annual report to the Water Quality Control Commission (WQCC) and Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment (CDPHE): Colorado Oil and Gas Conservation Commission, Department of Natural Resources, 28 January 2022, 33 p., https://cdphe.colorado.gov/sb-89-181-implementing-agencies-annual-reports.

COGCC, 2022d, Colorado Oil and Gas Conservation Commission hearings/rulemaking: Colorado Oil and Gas Conservation Commission, 6 p., https://cogcc.state.co.us/hearings.html#/rulemaking.

Colorado General Assembly, 2022, Legislative council staff severance tax website summary: https://leg.colorado.gov/agencies/legislative-council-staff/severance-tax.

Congress (U.S. Congress), 2019, S. 1386 – Hardrock Mining and Reclamation Act of 2019: U.S. Congress, https://www.congress.gov/bill/116th-congress/senate-bill/1386?s=1&r=7.

Congress, 2020, H.R. 2579 – Materials Act of 1947, Hardrock Leasing and Reclamation Act of 2019: U.S. Congress, https://www.congress.gov/bill/116th-congress/house-bill/2579.

Congress, 2021, H.R. 5033 – Rare earth magnet manufacturing production tax credit act of 2021: U.S. Congress, https://www.congress.gov/bill/117th-congress/house-bill/5033?s=1&r=40.

CPR (Colorado Public Radio), 2021, The end of an era: The Martin Drake Coal Plant in Colorado Springs burns coal no longer: Colorado Public Radio, 26 August 2021, https://www.cpr.org/2021/08/26/the-end-of-an-era-the-martin-drake-coal-plant-in-colorado-springs-burns-coal-no-longer/.

Dateline (Dateline Resources), 2022a, 2022 annual report: Dateline Resources, 59 p., https://www.datelineresources.com.au/.

Denver Post, 2017, Xcel Energy plans to retire two coal-fired plants in Pueblo, increase renewables: Denver Post, accessed December 2021, https://www.denverpost.com/2017/08/29/xcel-energy-pueblo-coal-plants-retiring/.

Dicken, C.L., Woodruff, L.G., Hammarstrom, J.M., and Crocker, K.E., 2022, GIS, supplemental data table, and references for focus areas of potential domestic resources of critical minerals and related commodities in the United States and Puerto Rico: U.S. Geological Survey data release, https://doi.org/10.5066/P9DIZ9N8.

DOE, 2020a, Department of Energy announces $122 million for regional initiative to produce rare earth elements and critical minerals: U.S. Department of Energy, 22 September 2021, https://www.energy.gov/articles/department-energy-announces-122-million-regional-initiative-produce-rare-earth-elements-and.

DOE, 2021, DOE awards $19 million for initiatives to produce rare earth elements and critical minerals: U.S. Department of Energy, 29 April 2021, https://www.energy.gov/articles/doe-awards-19-million-initiatives-produce-rare-earth-elements-and-critical-minerals.

DOE, 2022a, Inflation reduction act keeps momentum building for nuclear power: U.S. Department of Energy, 8 September 2022, https://www.energy.gov/ne/articles/inflation-reduction-act-keeps-momentum-building-nuclear-power.

DOE, 2022b, DOE releases first-ever comprehensive strategy to secure America's clean energy supply chain: U.S. Department of Energy, 24 February 2022, https://www.energy.gov/articles/doe-releases-first-ever-comprehensive-strategy-secure-americas-clean-energy-supply-chain.

DOI (U.S. Department of the Interior), 2022a, Mining law reform, statement of the deputy assistant secretary of land and minerals management: U.S. Department of the Interior, 12 May 2022, https://www.doi.gov/ocl/mining-law-reform#:~:text=May%2012%2C%202022&text=The%20law%20allowed%20citizens%20to,nominal%20cost%E2%80%94to%20encourage%20settlement.

DOI, 2022b, Interior department launches interagency working group on mining reform: U.S. Department of the Interior, 22 February 2022, https://www.doi.gov/pressreleases/interior-department-launches-interagency-working-group-mining-reform.

DOLA (Colorado Department of Local Affairs), 2021a, Colorado Department of Revenue annual report: 84 p., dated December 8th, https://cdor.colorado.gov/sites/revenue/files/documents/Annual_Report_2021.pdf.

DOLA, 2021b, Direct distribution of severance tax and federal mineral lease memo: Colorado Department of Local Affairs, 30 August 2021, see the link to historical distributions, 2021, link to "Final FY 2021 Direct Distribution memo", dated August 30th," https://cdola.colorado.gov/funding-programs/direct-distribution-severance-tax-federal-mineral-lease.

DOT (U.S. Department of Transportation), 2021, The Bipartisan Infrastructure Law will deliver for Colorado: U.S. Department of Transportation, 4 p., https://www.transportation.gov/sites/dot.gov/files/2021-11/Bipartisan_Infrastructure_Law_Colorado.pdf.

DRMS (Colorado Division of Reclamation, Mining and Safety), 2021a, accessed October 2021, https://www.colorado.gov/pacific/drms/data-search.

DRMS, 2022b, 2020 Production report data, non-coal sites, C.R.S. 34-24-101: Colorado Division of Reclamation, Mining and Safety, accessed December 2022, https://www.colorado.gov/pacific/drms/data-search.

Eckel, E.B., 1949, Geology and ore deposits of the La Plata District Colorado: U.S. Geological Survey Professional Paper 219, 179 p., https://pubs.usgs.gov/pp/0219/report.pdf.

Edison (Edison Investment Research), 2021, Global helium market update: market shifting to oversupply by mid-2020s: Edison Investment Research, May 2021, https://www.edisongroup.com/wp-content/uploads/2021/05/Helium_report050521_final.pdf.

EIA, 2020a, As U.S. coal-fired capacity and utilization decline, operators consider seasonal operation: U.S. Energy Information Administration, 1 September 2020, https://www.eia.gov/todayinenergy/detail.php?id=44976.

EIA, 2021a, Of the operating U.S. coal-fired power plants, 28% plan to retire by 2035: U.S. Energy Information Administration, dated 15 December 2021, https://www.eia.gov/todayinenergy/detail.php?id=50658#:~:text=As%20of%20September%202021%2C%20212,Preliminary%20Monthly%20Electric%20Generator%20Inventory.

EIA, 2021b, 2020 Uranium marketing annual report: U.S. Energy Information, 20 May 2021, https://www.eia.gov/uranium/marketing/.

EIA, 2022a, Proved reserves of crude oil and natural Gas in the United States, Year-End 2020: U.S. Department of Energy, 45 p., https://www.eia.gov/naturalgas/crudeoilreserves/pdf/usreserves.pdf.

EIA, 2022b, Annual coal report 2022, October 2022: U.S. Department of Energy, 67 p., https://www.eia.gov/coal/annual/.

EIA, 2022c, How much shale (tight) oil is produced in the United States: U.S. Energy Information Administration, accessed December 2022, updated 4 October 2022, https://www.eia.gov/tools/faqs/faq.php?id=847&t=6.

EIA, 2022d, Domestic crude oil first purchase prices by area: U.S. Energy Information Administration, accessed October 2022, https://www.eia.gov/dnav/pet/pet_pri_dfp1_k_a.htm.

EIA, 2022e, Proved reserves of crude oil and natural gas in the United States, year-end 2020: U.S. Energy Information Administration, January 2022, 45 p., https://www.eia.gov/naturalgas/crudeoilreserves/pdf/usreserves.pdf.

EIA, 2022f, Henry Hub natural gas spot price: U.S. Energy Information Administration, accessed October 2022, www.eia.gov/dnav/ng/hist/rngwhhda.htm.

EIA, 2021g, Colorado state profile and energy estimates: U.S. Energy Information Administration, accessed December 2021, https://www.eia.gov/state/?sid=CO.

EIA, 2022h, Annual coal distribution report: U.S. Energy Information Administration, 18 October 2022, https://www.eia.gov/coal/distribution/annual/.

EIA, 2022i, Electric power annual (see Table 3.1.A): U.S. Energy Information Administration, accessed December 2022, https://www.eia.gov/electricity/annual/.

EIA, 2022j, Nuclear explained, U.S. nuclear industry: U.S. Energy Information Administration, accessed December 2022, https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php.

EIA, 2022k, Frequently asked questions, how many nuclear power plants are in the United States, and where are they located: U.S. Information Administration, accessed December 2022, https://www.eia.gov/tools/faqs/faq.php?id=207&t=21.

EIA, 2022l, Domestic uranium production report – annual: U.S. Energy Information, website landing page accessed December 2021, https://www.eia.gov/uranium/production/annual/.

EIA, 2022m, Uranium marketing annual report: U.S. Energy Information, 26 May 2022, https://www.eia.gov/uranium/marketing/.

Federal Register, 2021a, 2021 Draft list of critical minerals: U.S. National Archives, 9 November 2021, https://www.federalregister.gov/documents/2021/11/09/2021-24488/2021-draft-list-of-critical-minerals.

FERC (Federal Energy Regulatory Commission), 2022, State of the markets 2021: Federal Energy Regulatory Commission, Office of Energy Policy and Innovation, Division of Energy Market Assessments, 21 April 2022, 32 p., https://www.ferc.gov/media/report-2021-state-markets.

Fortier, S.M., Nassar, N.T., Lederer, G.W., Brainard, Jamie, Gambogi, Joseph, and McCullough, E.A., 2018, Draft critical mineral list—Summary of methodogy 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, 15 p., https://doi.org/10.3133/ofr20181021.

Freeport (Freeport-McMoRan Inc.), 2022a, Form 10-K annual report: Freeport-McMoRan Inc., https://www.fcx.com/.

GSA (U.S. General Services Administration), 2022, Bipartisan Infrastructure Law (BIL) maps dashboard: U.S. General Services Administration, last data update 25 October 2022, https://d2d.gsa.gov/report/bipartisan-infrastructure-law-bil-maps-dashboard.

Georgia Power, 2022, Vogtle Unit 3 starts nuclear fuel load: Georgia Power, 14 October 2022, https://www.georgiapower.com/company/news-center/2022-articles/vogtle-unit-3-nuclear-fuel-load.html.

Guilinger, J.R., and Keller, J.W., 2015, Colorado mineral and energy activities 2014-2015: Colorado Geological Survey Information Series 78, 36 p., https://coloradogeologicalsurvey.org/publications/colorado-mineral-energy-industry-activities-2015/.

Hardy, M., Ramey, M., Yates, C, and Nielsen, K., 2003, Solution mining of nahcolite at the American Soda Project, Piceance Creek, Colorado: 2003 Society for Mining, Metallurgy & Exploration, Annual Meeting, Feb. 24-26, Cincinnati, Ohio, Preprint 03-104, https://www.agapito.com/wp-content/uploads/2010/05/Solution-Mining- of-Nahcolite.pdf.

HEM (Huber Engineered Materials), 2022, Huber Engineered Materials acquires Natural Soda LLC: https://www.hubermaterials.com/news/2022/huber-engineered-materials-acquires-natural-soda-llc.aspx.

Hickenlooper, J., 2022, Press release: one year into Bipartisan Infrastructure Law, Hickenlooper lauds $3 billion announced for Colorado so far: 15 November 2022, https://www.hickenlooper.senate.gov/press_releases/one-year-into-bipartisan-infrastructure-law-hickenlooper-lauds-3-billion-announced-for-colorado-so-far/.

Hofstra, A.H., and Kreiner, D.C., 2020, Systems-Deposits-Commodities-Critical Minerals Table for the Earth Mapping Resources Initiative: U.S. Geological Survey Open-File Report 2020–1042, 24 p., https://pubs.er.usgs.gov/publication/ofr20201042.

Johnson, R.C., Mercier, T.J., Ryder, R.T., Brownfield, M.E., and Self, J.G., 2011, Assessment of in-place oil shale resources in the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah, chapter 1 of Oil shale resources of the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah: U.S., Geological Survey Digital Data Series 69–DD, 63 p., https://pubs.usgs.gov/dds/dds-069/dds-069-dd/.

Kitco, 2022, The world's top 10 largest gold mining companies in 2021: Kitco Mining News, 9 March 2022, https://www.kitco.com/news/2022-03-09/The-world-s-top-10-largest-gold-mining-companies-in-2021-report.html.

Lien (Pete Lien and Sons), 2022, accessed December 2022, https://www.petelien.com/.

Mallory, W.W., 1971, The Eagle Valley Evaporite, Northwest Colorado – a regional synthesis: U.S. Geological Survey Bulletin 1311-E, 37 p., https://pubs.usgs.gov/bul/1311e/report.pdf.

McIntosh, W.C. and Chapin, C.E., 2004, Geochronology of the central Colorado vol- canic field: New Mexico Bureau of Geology and Mineral Resources, Bulletin 160, p. 205–237, https://geoinfo.nmt.edu/publications/monographs/bulletins/ downloads/160/ papers/10mcntsh.pdf.

Metallic Minerals (Metallic Minerals Corp.), 2022, Technical report on the inaugural mineral resource estimate for the Allard Cu-Ag Porphyry Deposit, La Plata project: Metallic Minerals Corp., 10 June 2022, https://mmgsilver.com/projects/laplata-1/property-overview/.

MineWater, 2022, Development programs: website accessed December 2022, https://www.minewater.com/minewaterfinance.

Nassar, N.T. and Fortier, S.M., 2021, Methodology and technical input for the 2021 review and revision of the U.S. critical minerals list: U.S. Geological Survey, Open-file report 2021-1045, 31 p., https://pubs.er.usgs.gov/publication/ofr20211045.

Newmont (Newmont Corporation), 2022, Form 10-K annual report: Newmont Corp- oration, https://newmont.com/.

O'Keeffe, M.K., 2022, Colorado mineral and energy activities 2020-2021: Colorado Geological Survey Information Series 84, 34 p., https://coloradogeologicalsurvey.org/publications/colorado-mineral-energy-industry-activities-2021/.

O'Keeffe, M.K., Peretyatko, A.I., and Berry, K.A., 2018, Colorado mineral and energy industry activities 2017-2018: Colorado Geological Survey Information Series 81, 29 p., https://coloradogeologicalsurvey.org/publications/colorado-mineral-energy-industry-activities-2018/.

O'Keeffe, M.K., Peretyatko, A.I., and Mahatma, A., 2021, Alkaline complexes of the Wet Mountains area, Colorado – A geological summary, bibliography, and data compilation of critical mineral laboratory results: Colorado Geological Survey Open-File Report OFR-20-11, 48 p., https://coloradogeologicalsurvey.org/publications/alkaline-complexes-critical-mineral-wet-mountains-colorado/.

O'Keeffe, M.K., Morgan, M.L., Keller, S.M., and Lindsey, K.O., 2022, Reconnaissance map of sand, gravel, and quarry aggregate resources, Elbert County, Colorado: Colorado Geological Survey ON-007-09D/M, 10 p., online map: https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html?id=9eff494fdf984a4d9cdec0f6299def18, data download: https://coloradogeologicalsurvey.org/publications/aggregate-resources-elbert-data/.

PCA (Portland Cement Association), 2022, accessed December 2022, https://www.cement.org/cement-concrete.

S&P (S&P Global Market Intelligence), 2022a, World exploration trends 2022: S&P Global Market Intelligence, April 2022, 17 p., https://www.spglobal.com/marketintelligence/en/news-insights/blog/world-exploration-trends-2022#:~:text=Exploration%20budgets%20increased%2035%25%20to,nearly%2070%25%20more%20than%202020.

Scarbrough Jr., L.A., 2001, Geology and mineral resources of Park County, Colorado: Colorado Geological Survey Resource Series 40, 89 p., https://coloradogeologicalsurvey.org/publications/geology-mineral-resources-park-colorado.

Schumer, C.E., 2022, Resources: Historic Omnibus Appropriations Agreement for FY2022: https://www.ncsl.org/ncsl-in-dc/publications-and-resources/2022-omnibus-appropriations-bill-a-summary-of-provisions-by-federal-agency.aspx, also see the summary of Energy and Water Development here: https://appropriations.house.gov/sites/democrats.appropriations.house.gov/files/Energy%20and%20Water%20Development%20and%20Related%20Agencies.pdf.

Schwochow, S.D., Shroba, R.R., and Wicklean, P.C., 1974, Sand, gravel, and quarry aggregate resources, Colorado Front Range counties, Colorado Geological Survey, Special Publication 5-A and 5-B, 47 p. and 220 p., respectively, https://coloradogeologicalsurvey.org/publications/atlas-sand-gravel-quarry-aggregate-colorado-front-range/.

SLB (Colorado State Land Board), 2021a, About the State Land Board: https://slb.colorado.gov/about.

SLB, 2021b, Annual report fiscal year 2020-2021: Colorado State Land Board, 15 p., https://slb.colorado.gov/reports.

SLB, 2021c, State Land Board income and inventory report, fiscal year 2020-21, annual review of income generated by State Trust lands: Colorado State Board of Land Commissioners, 21 p., https://slb.colorado.gov/reports.

Smith, M.E., Carroll, A.R., and Singer, B.S., 2008, Synoptic reconstruction of a major ancient lake system—Eocene Green River Formation, western United States: Geological Society of America Bulletin v. 120, nos. 1-2, p. 54–84, https://pubs.geoscienceworld.org/gsa/gsabulletin/article/120/1-2/54/125468/Synoptic-reconstruction-of-a-major-ancient-lake.

Sonnenberg, S.A., 2016, Stratigraphic architecture of the Niobrara Formation, Wattenberg Field Area, Colorado: SPE/AAPG/SEG Unconventional Resources Technology Conference, San Antonio, Texas, paper number URTEC-2435024_MS, 15 p., https://onepetro.org/URTECONF/proceedings/16URTC/All-16URTC/URTEC-2435024-MS/152101.

Streufert, R.K., 1999, Geology and mineral resources of Gunnison County, Colorado: Colorado Geological Survey Resource Series 37, 76 p., https://coloradogeologicalsurvey.org/publications/geology-mineral-resources-gunnison-colorado/.

Summit Brick Company, 2022, accessed December 2022, https://www.summitbrick.com/about.html.

Tumbleweed (Tumbleweed Midstream LLC), 2022, accessed December 2022, https://www.tumbleweedmidstream.com/newsroom/tumbleweed-midstream-formally-ends-sales-process-ladder-creek-helium-plant-and-gathering.

U.S. White House, 2021a, Executive order on America's supply chains: U.S. White House, 24 February 2021, https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/24/executive-order-on-americas-supply-chains/.

U.S. White House, 2021b, FACT SHEET: Biden-Harris administration announces supply chain disruptions task force to address short-term supply chain discontinuities: U.S. White House, 8 June 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/06/08/fact-sheet-biden-harris-administration-announces-supply-chain-disruptions-task-force-to-address-short-term-supply-chain-discontinuities/.

U.S. White House, 2021c, President Biden's Bipartisan Infrastructure Law: U.S. White House, https://www.whitehouse.gov/bipartisan-infrastructure-law/.

U.S. White House, 2022, Memorandum on presidential determination pursuant to Section 203 of the Defense Production Act of 1950, as amended: U.S. White House, https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/24/executive-order-on-americas-supply-chains/.

UAMMI (Utah Advanced Materials and Manufacturing Initiative), 2022, CORE-CM: UAMMI, website accessed December 2022, https://www.uammi.org/core-cm/.

University of Wyoming, 2022, Critical minerals and rare earth elements: Center for Economic Geology Research, accessed December 2022, https://www.uwyo.edu/cegr/research-projects/core-cm-ggrb.html.

USDR (U.S. Department of Revenue), 2022, Natural resources revenue data: U.S. Department of the Interior, U.S. Department of Revenue, https://revenuedata.doi.gov/, accessed October 2022.

USGS (U.S. Geological Survey), 2009, Nahcolite resources in the Green River Formation, Piceance Basin, Northwestern Colorado: U.S. Geological Survey, Oil Shale Assessment Project Fact Sheet 2009-3011, March 2009, https://pubs.usgs.gov/fs/2009/3011/pdf/FS09-3011.pdf.

USGS, 2013, In-place oil shale resources examined by grade in the major basins of the Green River Formation, Colorado, Utah, and Wyoming: U.S. Geological Survey Fact Sheet 2012-345, January 2013, 3 p., https://pubs.usgs.gov/fs/2012/3145/FS12-3145.pdf.

USGS, 2016, 2016 Assessment of continuous (unconventional) oil and gas resources in the Late Cretaceous Mancos Shale of the Piceance Basin, Uinta-Piceance Province, Colorado and Utah, 2016: U.S. Geological Survey Fact Sheet 2016-3030, 4 p., https://pubs.usgs.gov/fs/2016/3030/fs20163030.pdf.

USGS, 2019, Mineral commodity summaries 2019: U.S. Geological Survey, 200 p., https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs2019_all.pdf.

USGS, 2019, Assessment of undiscovered continuous tight-gas resources in the Mesaverde Group and Wasatch Formation, Uinta-Piceance Province, Utah and Colorado, 2018: U.S. Geological Survey Fact Sheet 2019-3027, May 2019, 2 p., https://pubs.usgs.gov/fs/2019/3027/fs20193027.pdf.

USGS, 2020a, Assessment of undiscovered oil and gas resources in the Mancos-Menefee Composite and underlying Todilto total petroleum systems of the San Juan Basin Province, New Mexico and Colorado, 2020: U.S. Geological Survey Fact Sheet 2020-3049, November 2020, 3 p., https://pubs.usgs.gov/fs/2020/3049/fs20203049.pdf.

USGS, 2020b, Assessment of undiscovered gas resources in the Lewis Shale total petroleum system of the San Juan Basin Province, New Mexico and Colorado, 2020: U.S. Geological Survey Fact Sheet 2020-3048, 2 p., https://pubs.usgs.gov/fs/2020/3048/fs20203048.pdf.

USGS, 2020c, Assessment of undiscovered gas resources of the Fruitland total petroleum system, San Juan Basin Province, New Mexico and Colorado, 2020: U.S. Geological Survey Fact Sheet 2020-3047, 2 p., https://pubs.usgs.gov/fs/2020/3047/fs20203047.pdf.

USGS, 2022a, Mineral commodity summaries 2022: U.S. Geological Survey, 202 p., https://pubs.er.usgs.gov/publication/mcs2022.

USGS, 2022b, National oil and gas assessments online map: U.S. Geological Survey, https://certmapper.cr.usgs.gov/data/apps/noga-drupal/.

USGS, 2022c, Crushed stone and sand and gravel in the first quarter 2022: U.S. Geological Survey, 7 p., https://www.usgs.gov/centers/national-minerals-information-center/crushed-stone-statistics-and-information.

USGS, 2021c, Mineral industry surveys, cement in September 2021: U.S. Geological Survey, December 2021, 33 p., https://www.usgs.gov/centers/national-minerals-information-center/cement-statistics-and-information.

USGS, 2022d, Mineral industry surveys, cement in February 2022: U.S. Geological Survey, 27 p., https://www.usgs.gov/centers/national-minerals-information-center/cement-statistics-and-information.

USGS, 2022e, 2018 Minerals Yearbook, clay and shale [advance release]: U.S. Geological Survey, dated March 2022, 20 p., https://www.usgs.gov/centers/national-minerals-information-center/clays-statistics-and-information.

Vail Daily, 2021, American Gypsum nets county approval for 99-acre expansion: Vail Daily, Pam Boyd, 15 September 2021, https://www.vaildaily.com/news/eagle-valley/american-gypsum-nets-county-approval-for-99-acre-expansion/.

Viscount (Viscount Mining Corp.), 2022a, Viscount Mining completes 4 phase drilling program required for resource update at the Kate deposit, Silver Cliff, Colorado: Viscount Mining Corp., accessed 17 November 2022, https://viscountmining.com/viscount-mining-completes-4-phase-drill-program-required-for-resource-update-at-the-kate-deposit-silver-cliff-colorado/.

Viscount, 2022b, Viscount Mining TITAN MT survey confirms significantly large conductive anomaly indicating likely porphyry at Silver Cliff, Colorado: Viscount Mining Corp., accessed 17 November 2022, https://viscountmining.com/viscount-mining-titan-mt-survey-confirms-significantly-large-conductive-anomaly-indicating-likely-porphyry-at-silver-cliff-colorado/.

Widmann, B.L., 2002, Sand and gravel resources adjacent to the Colorado River valley, Garfield County, CO: Colorado Geological Survey Open-File Report OF-02-12, https://coloradogeologicalsurvey.org/publications/sand-gravel-resources-garfield-colorado-river-valley-garfield-colorado/

Xcel (Xcel Energy), 2022, 2021 Clean energy plan, transitioning out of coal responsibly information sheet: Xcel Energy, https://co.my.xcelenergy.com/s/environment/clean-energy-plan.

Zou, C., 2017, Unconventional petroleum geology: 2nd Edition, Petroleum Industry Press, Elsevier Inc., 500 p.