

INFORMATION SERIES 86

Colorado Mineral and Energy Industry Activities 2022-2023

by Michael K. O'Keeffe



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Matthew L. Morgan
DIRECTOR and
STATE GEOLOGIST

Design/layout by Larry Scott

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EXECUTIVE SUMMARY and TAX REVENUE

The Colorado Geological Survey (CGS) estimates the total value of 2022 mineral and energy fuels production in Colorado to be \$30.53 billion, a ~49% increase from the 2021 estimate of \$20.51 billion mainly due to higher average prices for oil and natural gas. In 2022, 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 rock. Estimated mineral production values for 2022 are shown by commodity type in **Figure ES-1**. Oil and natural gas production accounted for ~90% of Colorado's total mineral and energy production value in 2022. Estimated mineral and energy production values for 1994 through 2022 are shown in **Figure ES-2**.

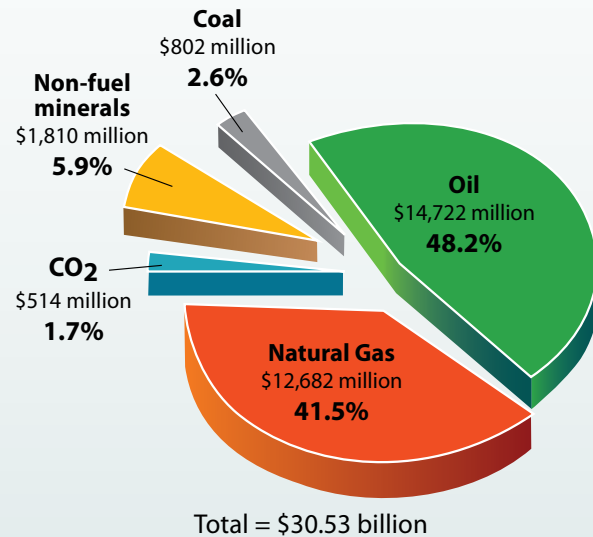


Figure ES-1. 2022 Colorado mineral production value by commodity type (U. S. dollars).

The total value of Colorado oil and natural gas production in 2022 is ~\$27.4 billion which is ~51.8% higher than last year's value of ~\$18.05 billion. Although production is lower than in 2019, oil and natural gas production remains higher than historical values and production values have increased due to inflation, 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, 2023a). The estimated value of Colorado coal production in 2022 is \$802 million which is ~43.5% higher than the 2021 value of ~\$559 million. Coal production values increased due to higher prices as production in 2022 was similar to 2021.

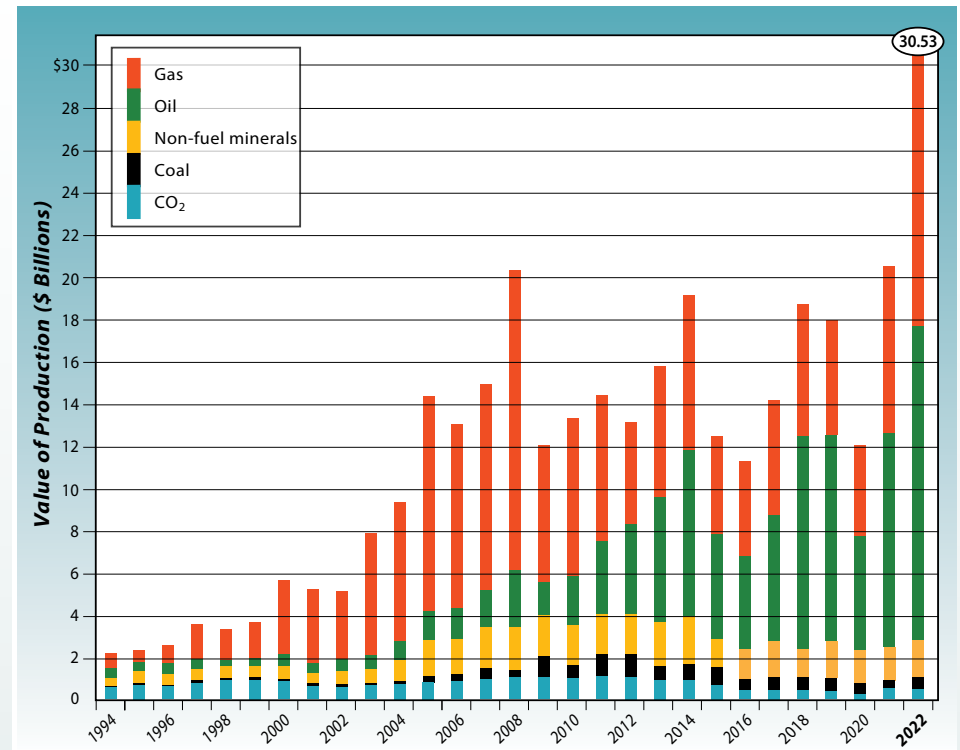


Figure ES-2. Mineral and energy fuel production value in Colorado, 1994–2022.

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 2022, Colorado is the 10th largest coal producer in the U.S. (EIA, 2023b) with both underground and surface mines currently in operation.

Non-fuel mineral production includes metals (molybdenum and gold), 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 2022 is \$1.81 billion (USGS, 2023a). Colorado is the third largest gold producer in the U.S., behind Nevada and Alaska, based on the total 2022 production from a single mine. Two Colorado mines continue to produce molybdenum and the state was the largest domestic producer of this metal in 2022. Although Colorado has been a producer in the past, there was no uranium mine production within the state in 2022.

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 2022 is \$514 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).

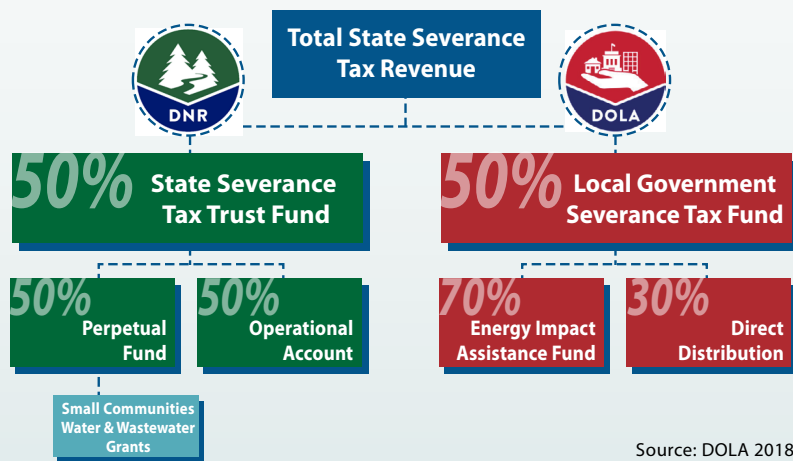


Figure ES-3. Distribution of state severance tax revenue in Colorado.

The Colorado Department of Local Affairs (DOLA) administers the distribution of severance tax revenue to county and local governments. In fiscal year (FY) 2021/2022 (21/22), July 1st through June 30th, Colorado net severance tax collections from metal, coal, and oil/gas producers is ~\$306.8 million (DOLA, 2022). About 98% of these tax collections are from oil and gas operations. **Figure ES-4** shows the severance taxes collected by fiscal year since 1994. In FY 22/23, ~\$54 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 22/23.

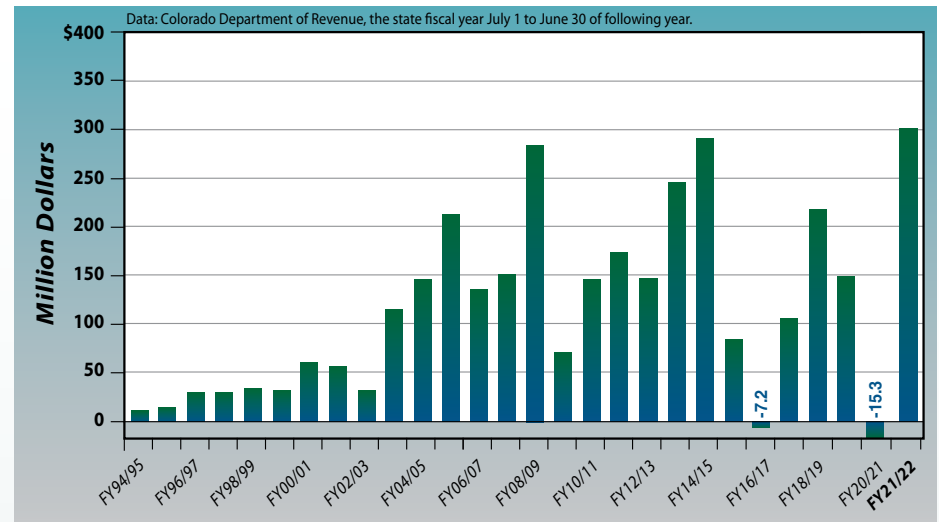


Figure ES-4. Colorado net severance tax collections FY94/95-FY21/22 (NOTE: In FY16/17 and in 20/21, severance refunds exceeded collections, hence the negative value).

The State of Colorado owns ~2.8 million surface acres and ~4 million subsurface (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 21/22, the Colorado state trust assets were valued at \$4.2 billion and SLB assets generated \$246.6 million in gross revenue (SLB, 2022a). 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 21/22, the SLB provided \$113.9 million to the BEST program (SLB, 2022a). Also, the SLB’s financial assets are associated with the Public School Permanent Fund which provides revenue to Colorado public schools. In FY 21/22, the SLB received ~\$175.3 million in mineral revenue (SLB, 2022b). The revenues include the following: oil and natural gas royalties and rentals, ~\$166.258 million; coal, ~\$3.541 million; other minerals, ~\$2.217 million; and other revenues, ~\$3.321 million (SLB, 2022b). **Figure ES-6** shows the SLB revenues from FY 96/97 to FY21/22.

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

Severance Tax Distribution by County

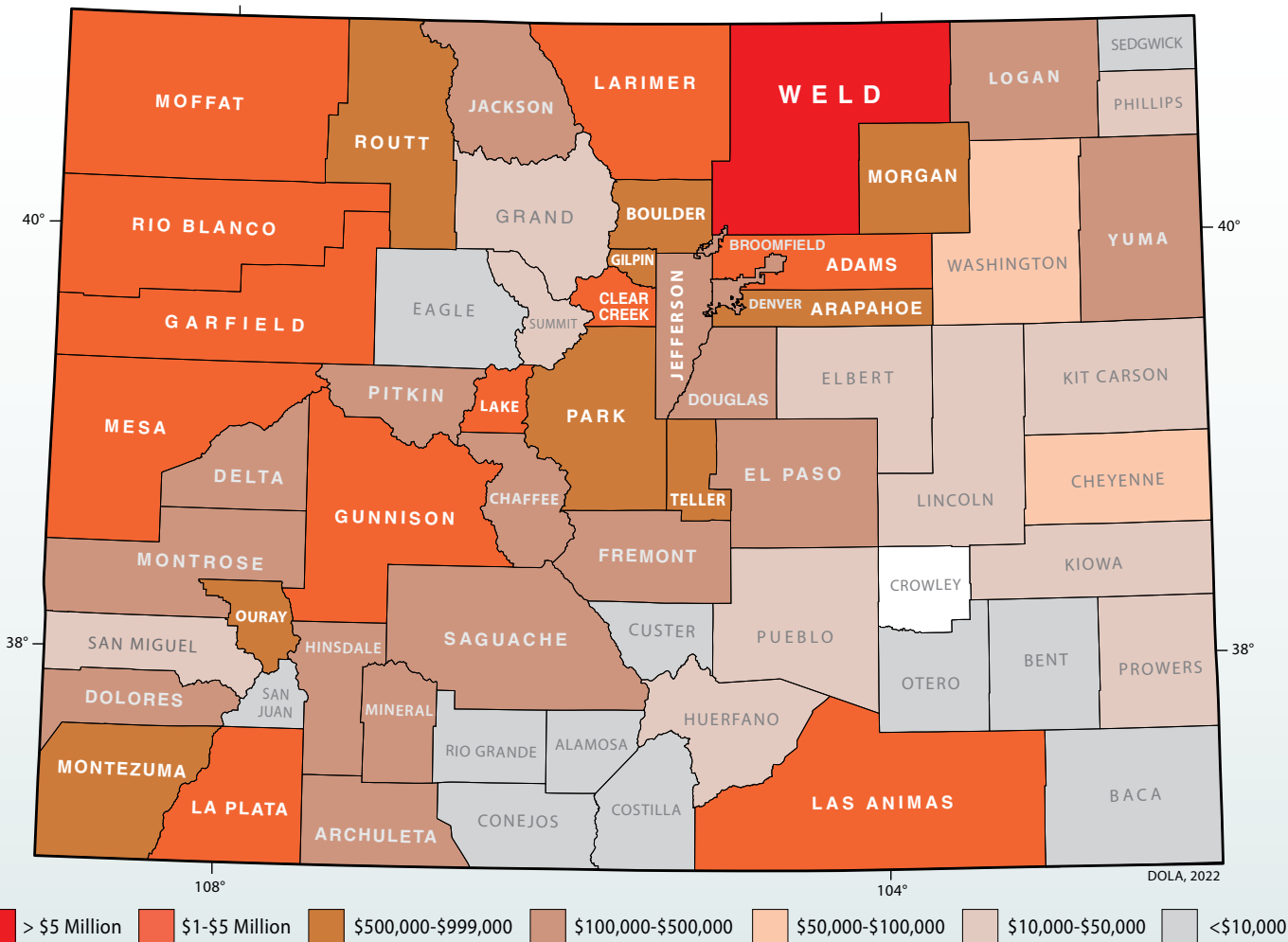


Figure ES-5. Colorado mineral severance tax distributions by county, FY 22/23.

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 2022, federal mineral lease revenues generated totaled ~\$393 million with ~\$143 million disbursed back to the state (U.S. Department of Revenue [USDR], 2023). **Figure ES-7** shows the revenue from federal mineral leases from 2009 to 2022.

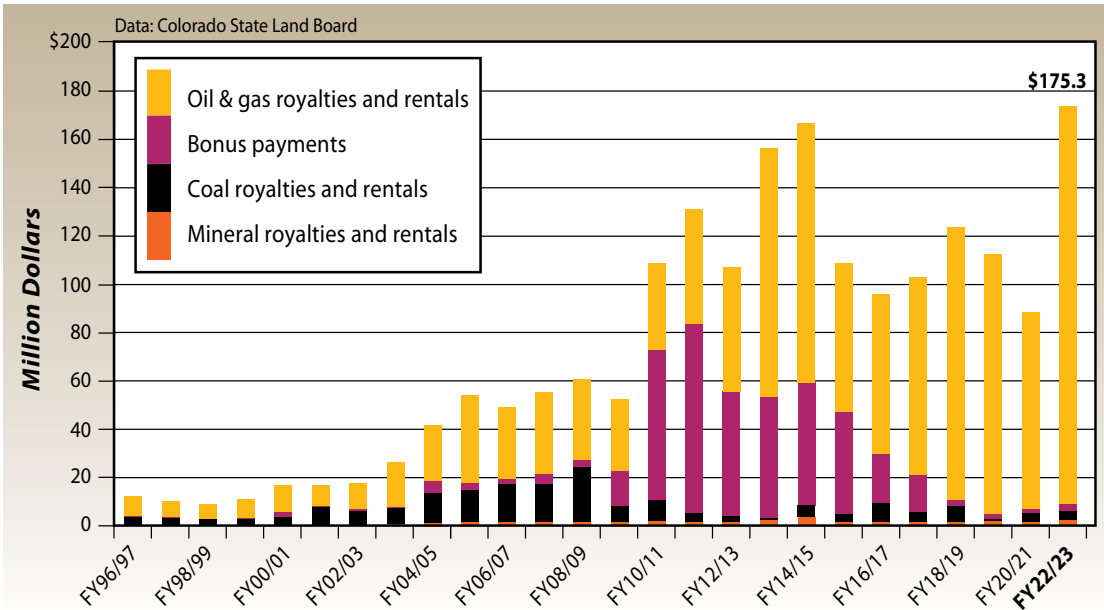


Figure ES-6. Colorado State Land Board (SLB) mineral revenues.

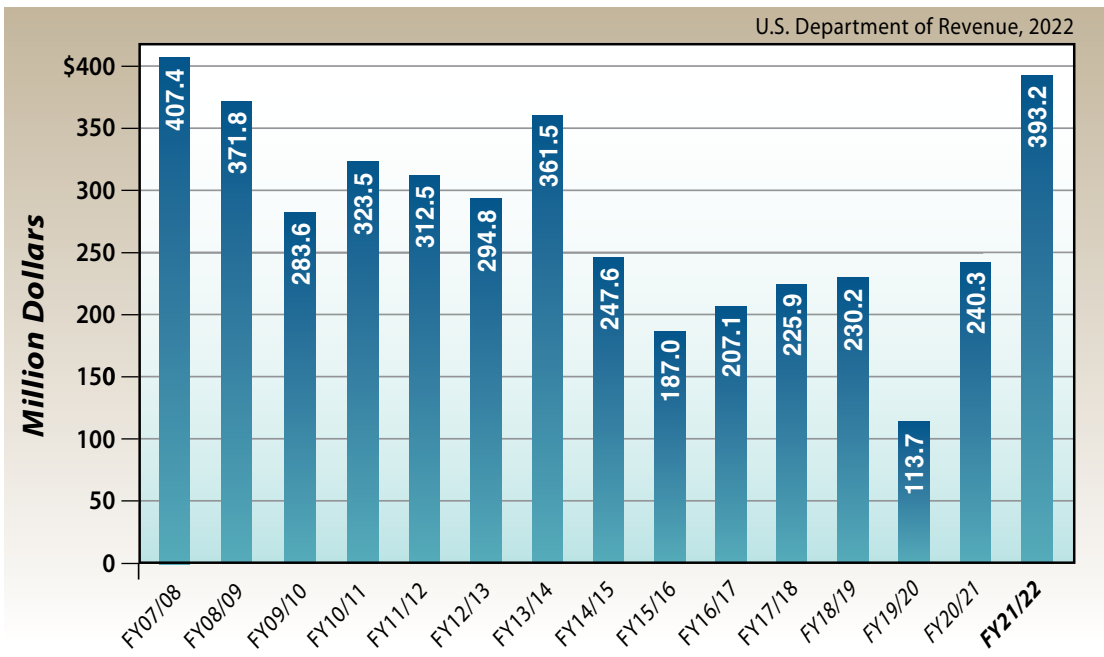


Figure ES-7. Federal mineral lease revenue generated in Colorado (50% is distributed to the state).

CONVENTIONAL ENERGY RESOURCES: PETROLEUM

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 2022 oil and natural gas approved drilling permits (Colorado Energy and Carbon Management Commission [ECMC], 2023a). According to the U.S. Department of Energy (DOE), Energy Information Agency (EIA), ~66% of the total U.S. crude oil production in 2022, ~2.84 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. 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.

Average crude oil spot prices increased in 2022 and decreased in 2023 (EIA, 2023d). Average

Oil & Gas Well Drilling Permits in Colorado

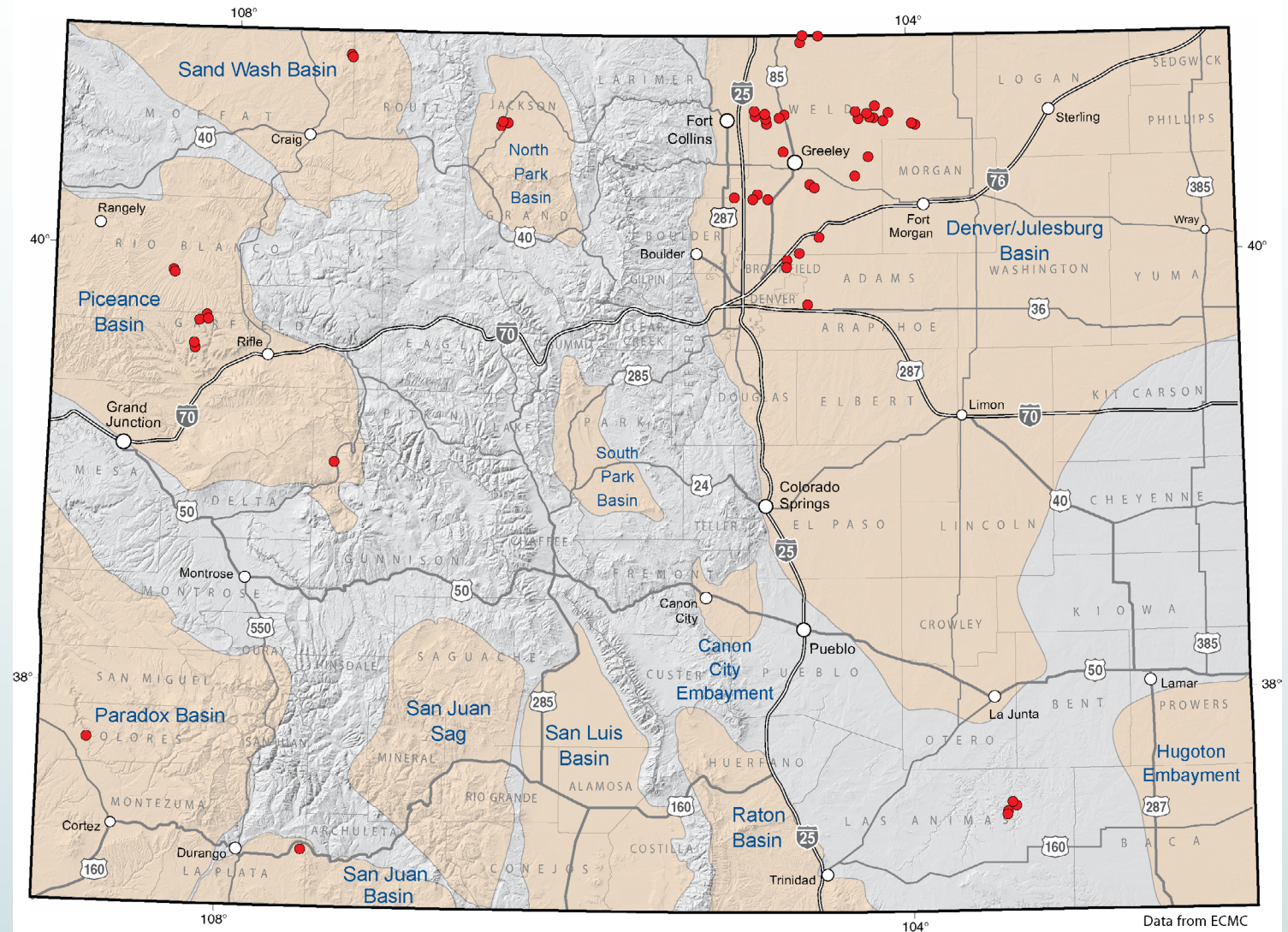


Figure 1. Sedimentary basins and the location of oil and gas well drilling permits (red dots) approved January 2022 to December 2022.

annual oil prices increased in 2022 to \$91.84 per barrel (EIA Colorado Domestic Crude Oil First Purchase Price) from an average of \$65.94 in 2021 (EIA, 2023e). Using this price and the Colorado Energy and Carbon Management Commission (ECMC) production estimate (ECMC, 2023a), the estimated overall oil production value in 2022 for Colorado is \$14.7 billion, an increase of ~45% when compared to the 2021 estimated oil production value of \$10.13 billion (Figure 2). Estimated oil production in Colorado between 2021 and 2022 increased by over 6.6 million barrels to ~160.3 million barrels. Oil production in Colorado and the average annual price per barrel over time are shown in Figure 3. At the end of 2022, Colorado ranked eighth among the top ten states with estimated proven oil reserves of ~1.488 billion barrels of oil (BO) (Figure 4). Texas ranked first with estimated proven oil reserves of 18.620 BO (EIA, 2023f).

The 2021 average spot price for natural gas was \$6.70 per thousand cubic feet (Mcf) (based on a heat content of 1.038 British Thermal Units per Mcf) (EIA, 2023g) (Figure 5). This natural gas price is ~42% higher than the 2021 average spot price of \$3.89 Mcf reported last year (O’Keeffe, 2023). In 2022, the annual spot price average price for natural gas was the highest since 2008 (EIA, 2023h). Colorado’s natural gas production decreased from ~1,958 billion cubic feet (Bcf) in 2021 to ~1,894 Bcf in 2022 (ECMC, 2023a).

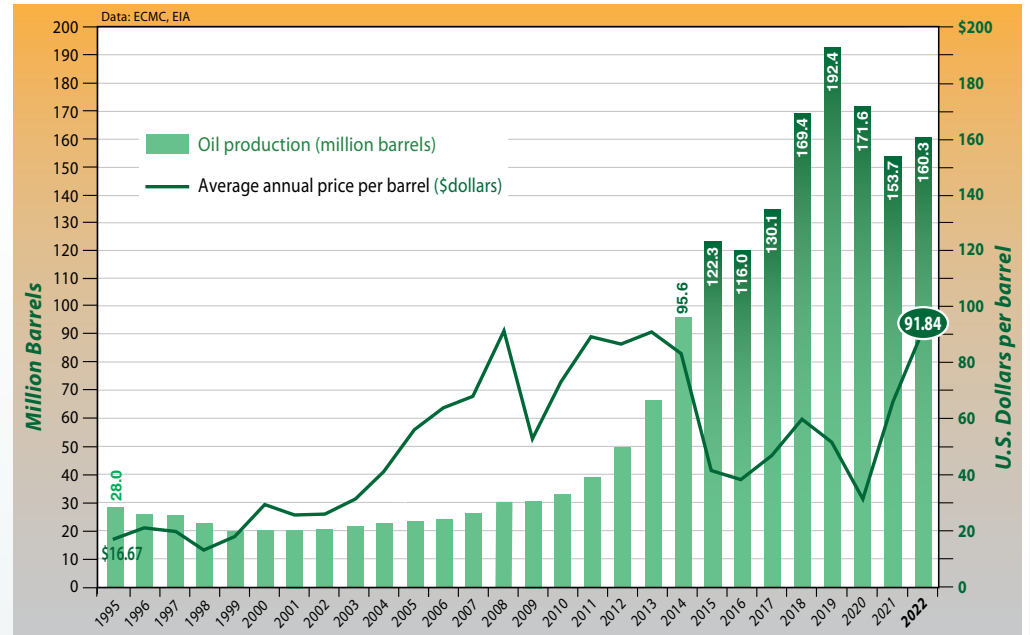


Figure 3. Colorado oil production and average annual price per barrel, 1995–2022.

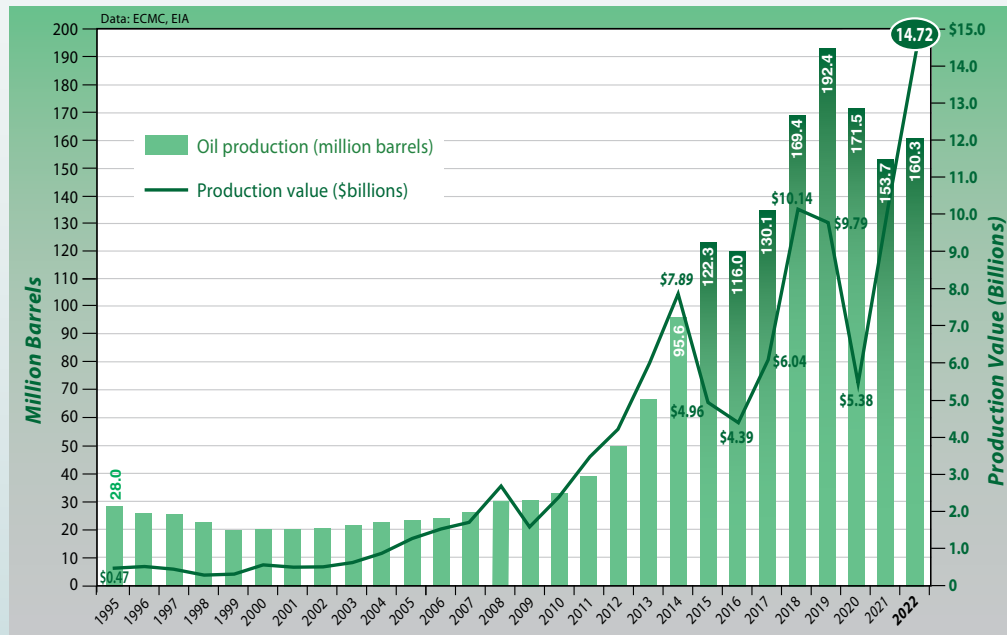


Figure 2. Oil production and estimated production value in Colorado, 1995–2022.

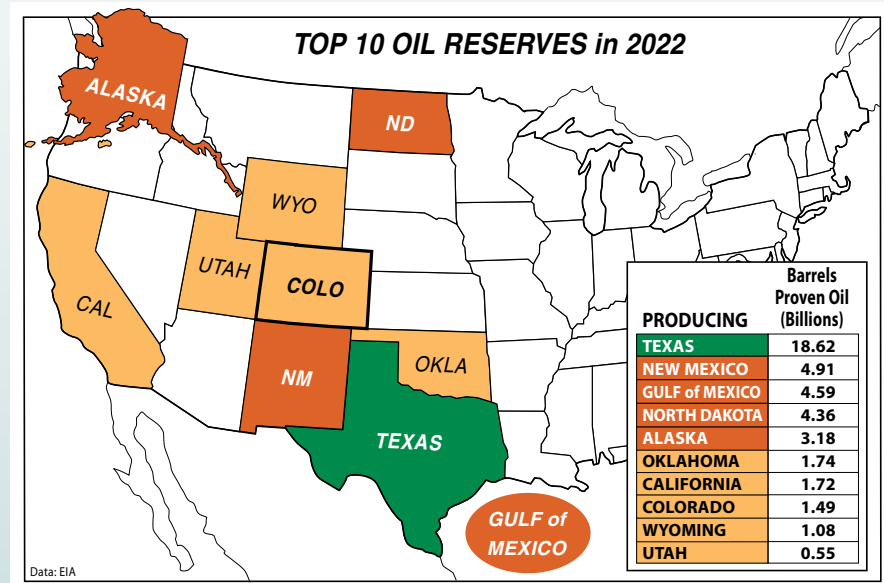


Figure 4. Top 10 states (including the Gulf) with proven oil reserves in 2022.

The estimated total 2022 natural gas production value in Colorado, using the Henry Hub spot price (EIA, 2023g) and ECMC production data (ECMC, 2023a), is \$12.68 billion. This is an increase of ~60% compared to the 2021 estimated natural gas production value of \$7.91 billion (O’Keeffe, 2023). At the end of 2021, Colorado had estimated proved natural gas resources of 22,071 Bcf, which

was the ninth largest in the U.S. (EIA, 2023f) (Figure 6). Texas ranked first with estimated proved natural gas reserves of 149,062 Bcf.

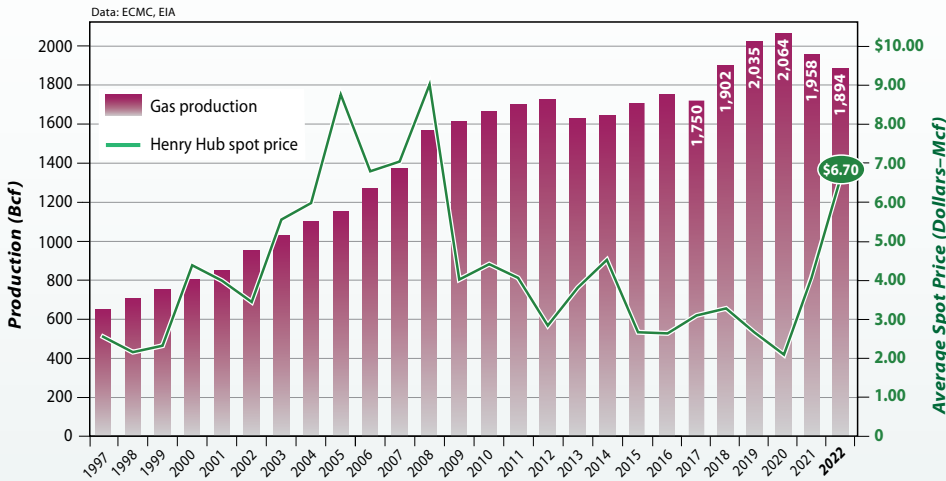


Figure 5. Colorado natural gas production and average price, 1997-2022.

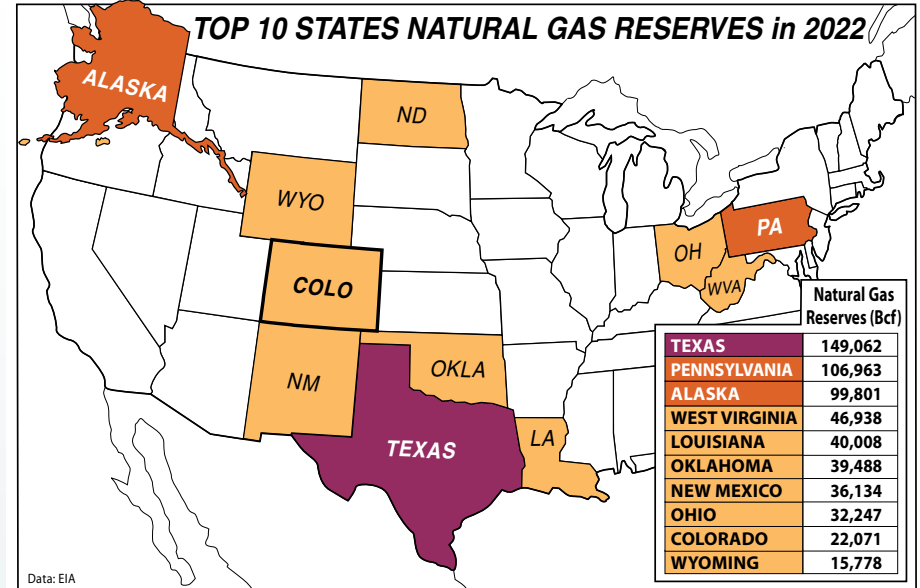


Figure 6. Top 10 states with proven natural gas reserves in 2022 (year’s end).



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, which 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 ~10.2% of the total natural gas production (194 Bcf) in 2022 (ECMC, 2023a). This decline is largely due to the increase of general natural gas production as well as the development of unconventional reservoirs using horizontal drilling and hydraulic fracturing techniques.

County Rankings – Oil and Natural Gas Production

Colorado produced ~31% more crude oil in 2022 than it did ten years ago in 2012 mostly due to the increased use of horizontal drilling and fracturing techniques. Thirty-six of Colorado's 64 counties produced crude oil and/or natural gas in 2022. To rank each county's contribution to the state's total production value, production from each county was multiplied by average annual prices. The EIA 2022 Colorado First Purchase price of \$91.84 per BO for the average annual price of oil (EIA, 2023e) and the average spot price for natural gas of \$6.70 per Mcf (EIA, 2023d) were used with the ECMC (2023a) production totals to calculate the production values. The total 2022 estimated oil and natural gas production value for Colorado is ~\$27.4 billion. **Figure 8** shows the estimated total oil and natural gas production value by county.

As it has been for many years, Weld County is the single largest producer of oil and natural gas in Colorado with an estimated total production value of ~\$18.673 billion in 2022. 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 one of the top ten oil and natural gas fields based on proved reserves (EIA, 2023i). 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). In the Denver Basin (a large asymmetric basin formed largely during the Laramide orogeny), the Niobrara Formation (~82 to 89.5 Ma) was deposited in the Western Interior Seaway during a major marine transgression and consists of deep-water chalks and marl units (Sonnenberg, 2016).

In 2022, Garfield County (located in western Colorado), has the second largest natural gas and oil production value with an estimated total of \$2.589 billion. La Plata County ranks third in natural gas and oil production value with an estimated total of ~\$1.411 billion. Most of the production value in both counties is from the production of natural gas (~96 and ~99%, respectively). Adams and Rio Blanco counties have a combined oil and natural gas production value of \$2.21 billion. **Figures 9 and 10** show the estimated oil and natural gas production by county for 2022, respectively.

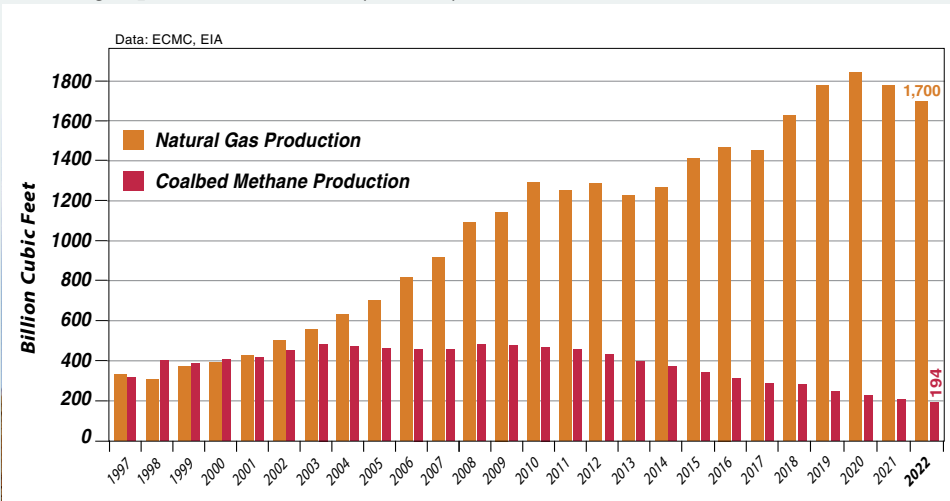
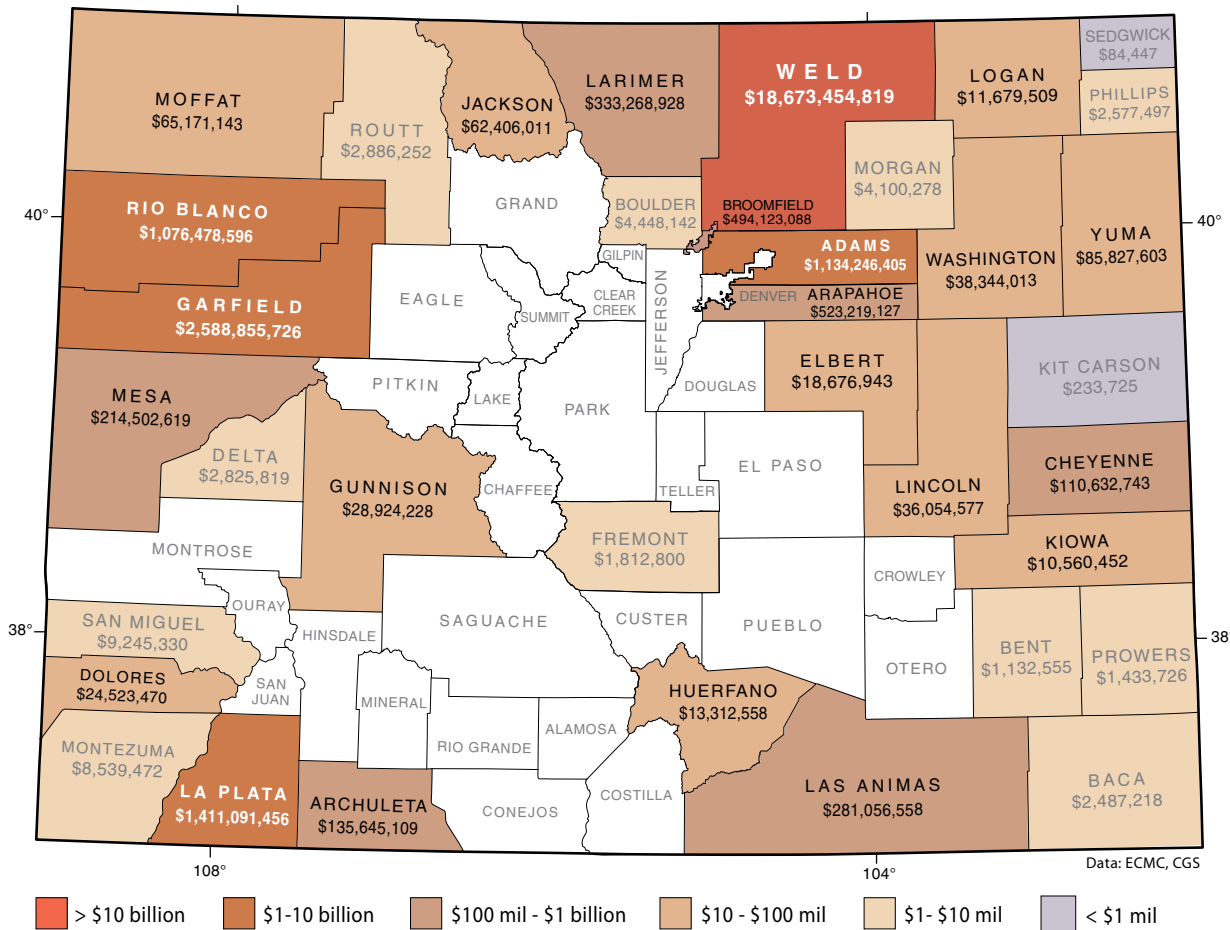


Figure 7. Coalbed methane vs. non-coalbed natural gas production in Colorado, 1997-2022.



Estimated 2022 Oil and Gas Production Value by County



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. The ECMC received 1,810 applications for drilling permits in 2022, a ~164% increase from 2021. Sixty percent of the approved well permits were in Weld County, followed by Garfield County (11%), La Plata County (8%), and Adams County (6%) (ECMC, 2023b). **Figure 11** shows the number of annual oil and natural gas drilling permits in Colorado from 1994 to 2022.

Oil Shale

Oil shale is different from oil produced from shale reservoirs. Currently, oil shale resources have not been developed in Colorado. 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)

Figure 8. Estimated oil and natural gas production value by county in Colorado, 2022.



2022 Oil Production (barrels) by County

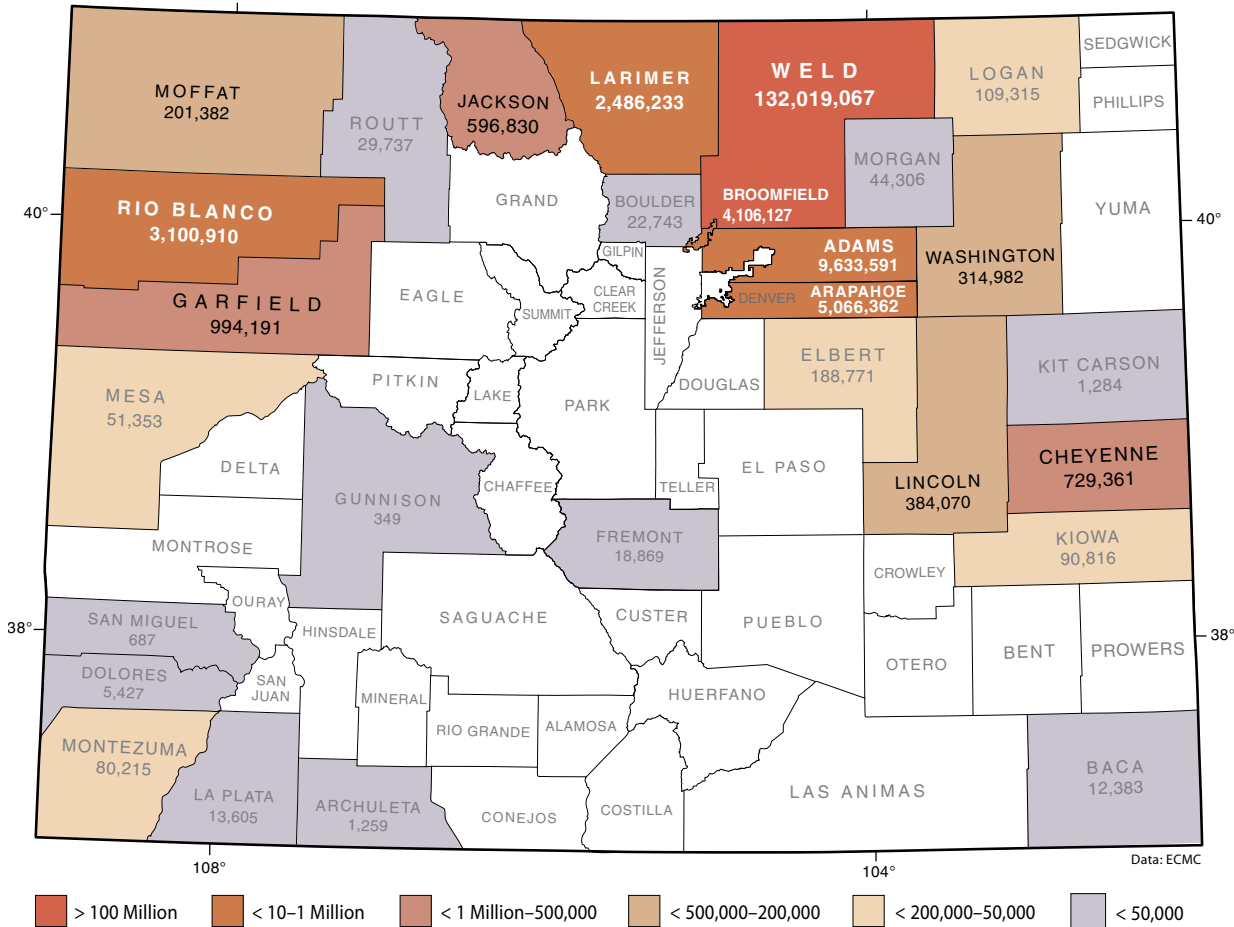


Figure 9. Total oil production by county in Colorado, 2022.

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).

ECMC Regulations

The ECMC officially changed its name from the Colorado Oil and Gas Conservation Commission in July 2023. As reported in previous MEIA reports (O’Keeffe, 2022; 2023), Colorado Senate Bill (SB) 19-181 passed in 2019 requires the ECMC to place more emphasis on public and environmental health and safety and addressing cumulative impacts from oil and gas activities. Additionally, the new law redefined the agencies mission which is now to “regulate the development and production of the natural resources of oil and gas in the state of Colorado in a manner that protects public health, safety, welfare, the environment and wildlife resources.” More information on the ECMC’s mission change and rulemaking efforts can be found here:

<https://ecmc.state.co.us/hearings.html#/overview>



2022 Natural Gas Production (Bcf) by County

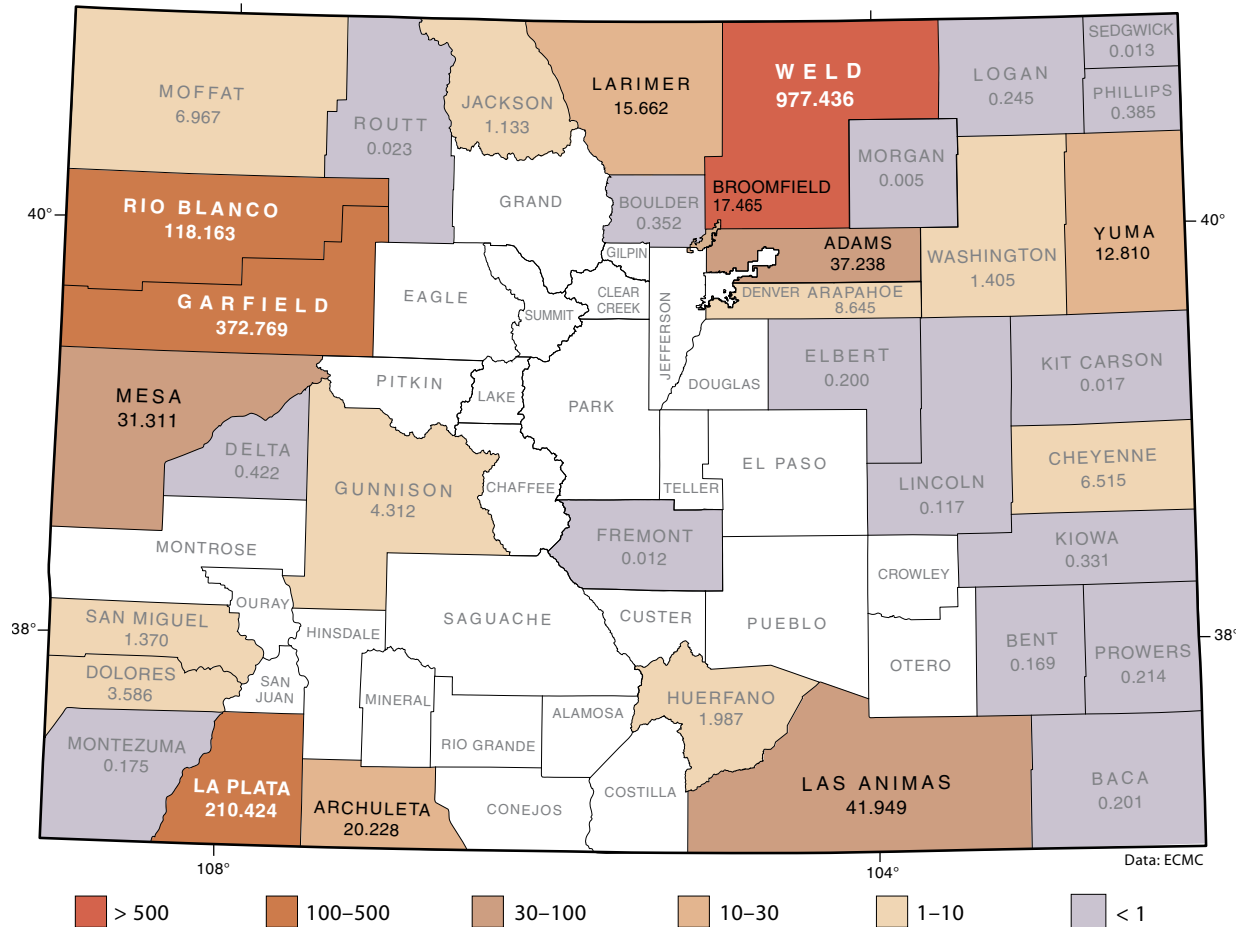
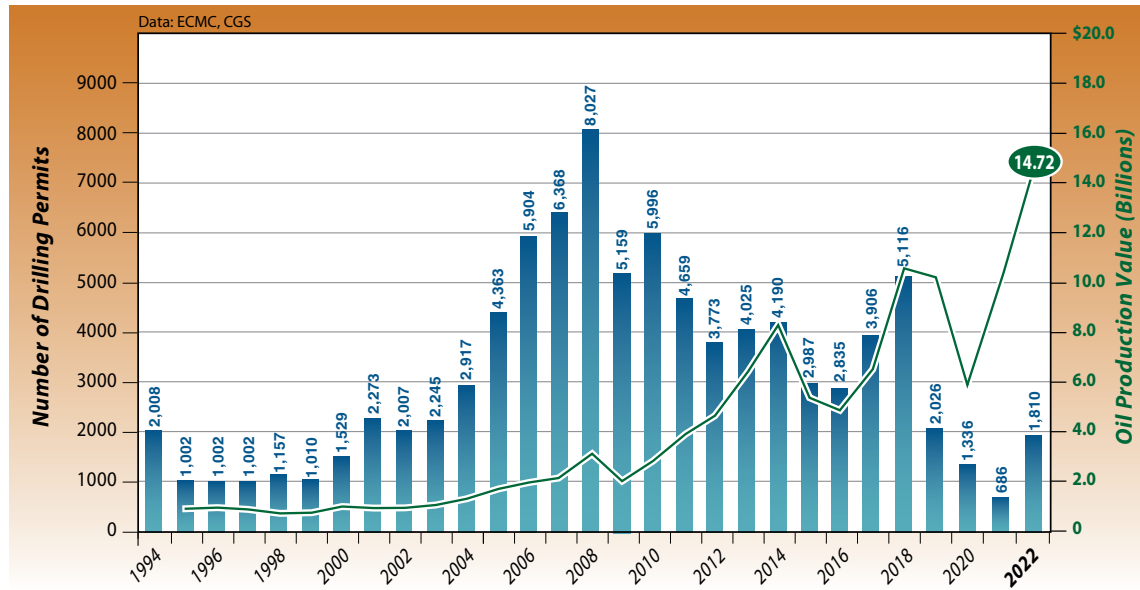


Figure 10. Total natural gas production (Bcf) by county in Colorado, 2022.

As reported by the ECMC (ECMC, 2023b):

“As a result of this Mission Change, the Commission undertook rulemakings for Flowlines, Practice and Procedure, Alternative Location Analysis, Cumulative Impacts and more generally, “Mission Change.” Finally in 2021 and 2022, the Commission conducted an overhaul of the Financial Assurance rules. The Commission gave direction to Staff for this rulemaking to reflect the spirit and mandates of SB 19-18. Significant changes and protections from this rulemaking include:

- Ensuring each operator has the financial capability to meet all of their obligations under the Act through the development of a first-ever individual operator-specific financial assurance plan requirement;
- Increasing financial assurance for transferred and inactive wells;
- Requiring financial assurance accounts for new wells funded in the initial years of operations;
- Creating an orphan well fund;
- Applying Colorado’s new Financial Assurance rules to Federal wells for the first time;
- Broadening access for local governments regarding plugging of wells; and
- Developing a first in the nation out-of-service plugging program.”



11. Annual oil and gas drilling permits in Colorado, 1994-2022.

Figure 11. Annual oil and gas drilling permits and oil production value in Colorado, 1994-2022.



CONVENTIONAL ENERGY RESOURCES: COAL

Domestic coal production increased 2.9% in 2022 compared to 2021 due to several factors including the replenishment of coal stockpiles at power plants which were drawn down in 2021 as well as higher natural gas prices (EIA, 2023i; EIA, 2023j; EIA, 2023k). Although U.S. coal production has generally decreased since 2012, coal is still a significant source of Colorado's electrical power. In 2022, coal-fired plants provided ~36% of Colorado's electricity (EIA, 2023i) while 37% of electric generation was from renewable sources, especially wind (28%) and solar power (EIA, 2023i). 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. In 2022, domestic renewable electric generation surpassed coal and nuclear in the power sector for the first time (EIA, 2023l).

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, 2020). 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, 2020). As of September 2021, ~212 GW of coal-fired generating capacity was operating in the U.S. (EIA, 2021a). U.S. operable utility-scale coal-fired generating capacity was ~202 GW as of June 2022 (EIA, 2022).

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. The last several MEIA reports give a summary of these shutdowns/conversions since 2012 (O'Keeffe, 2023). Several coal-fired plants will retire in the future:

- 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 (Tristate, 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 was demolished in 2022. Six modular natural gas power generating units were installed outside the old plant and may be moved to different portions of the electrical grid in the future (Gazette, 2023).
- The Pawnee Station will convert to natural gas by 2026 (Xcel, 2022).

Power generation in Colorado consumes about 47% of the coal mined in the state. The rest is shipped to ~17 other states or exported to other countries (~2.2 million tons in 2022) (EIA, 2023m). 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 2022 is 12.33 million tons (DRMS, 2023). The estimated value of Colorado coal production in 2022 is \$802 million (Figure 12 and Table 1) and the estimated average value of a ton of Colorado coal is \$65.00 (EIA, 2023b). Colorado coal production and average prices since 2001 are shown in Figure 13. In 2022, seven Colorado coal mines were active (Table 2) employing 1,093 coal miners (DRMS, 2023) (Figure 14).

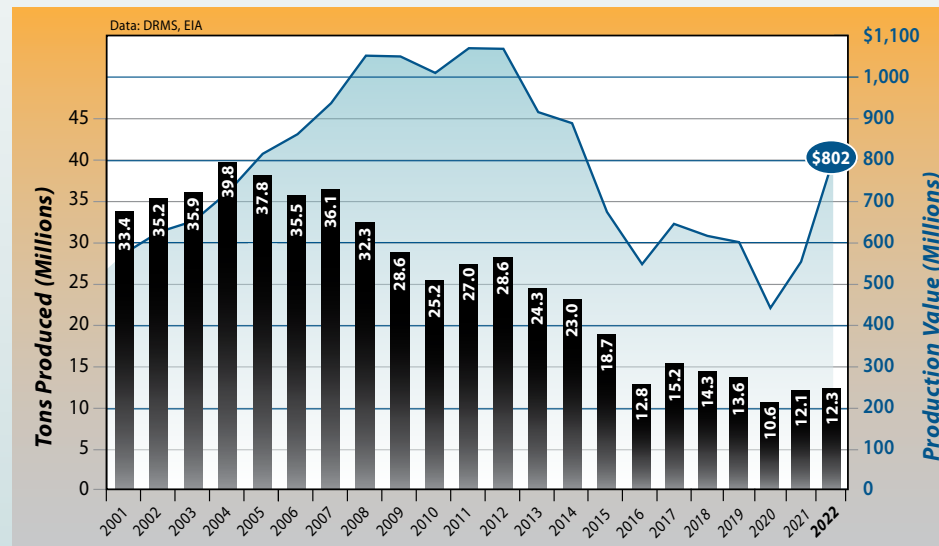


Figure 12. Production and value of coal mined in Colorado, 2001–2022.

Table 1. Coal production, price, value, and employment, 2002–2022.

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
2022	12.33	\$65.00	\$802	1,093

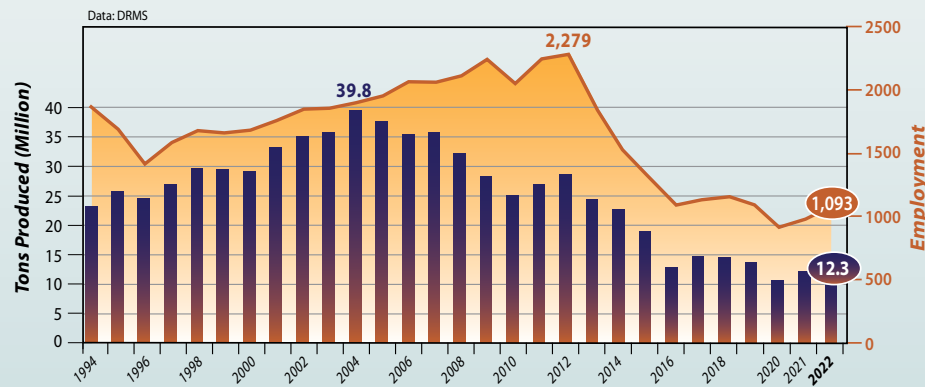


Figure 14. Coal production and employment in Colorado, 1994–2022.

In 2022, Colorado was ranked 10th in coal production in the U.S. (Figure 15) (EIA, 2023b). Wyoming, the leading U.S. producer by far (~244.7 million tons), mined over 19 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 plant closing dates are shown on Figure 16.

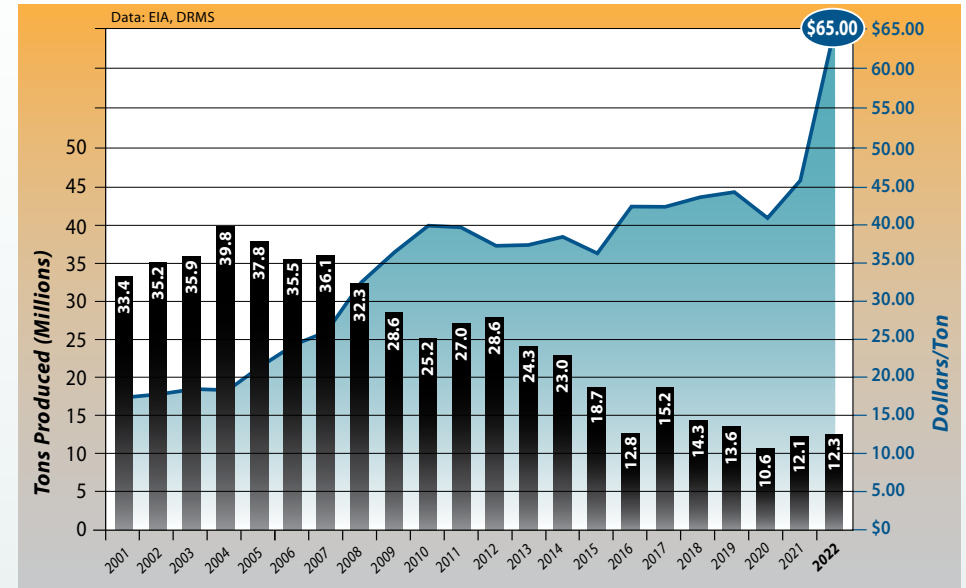


Figure 13. Coal production and average annual coal price in Colorado, 2001–2022.

Table 2. Active coal mines in Colorado, 2022.

Mine	Operator	County	Mine Type	2022 Prod. (tons)
New Elk Mine	Basin Resources	Las Animas	Underground	217,680
Colowyo	Colowyo Coal Co. L.P.	Moffat	Surface	1,684,455
Deserado	Blue Mountain Energy	Rio Blanco	Underground	2,597,403
Foidel Creek	Twentymile Coal Co./Peabody Energy	Routt	Underground	1,536,078
King II	GCC Energy LLC	La Plata	Underground	471,934
Trapper	Trapper Mining Inc.	Moffat	Surface	1,430,739
West Elk	Mountain Coal Co./Arch Coal	Gunnison	Underground	4,395,403
Total				12,333,692

Data: DRMS

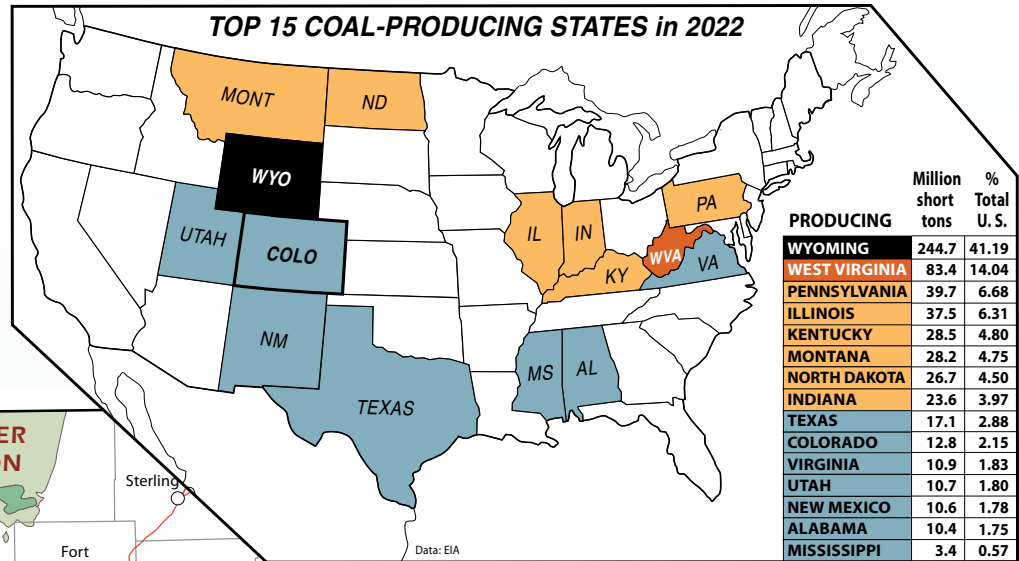


Figure 15. Top 15 coal-producing states in 2022.

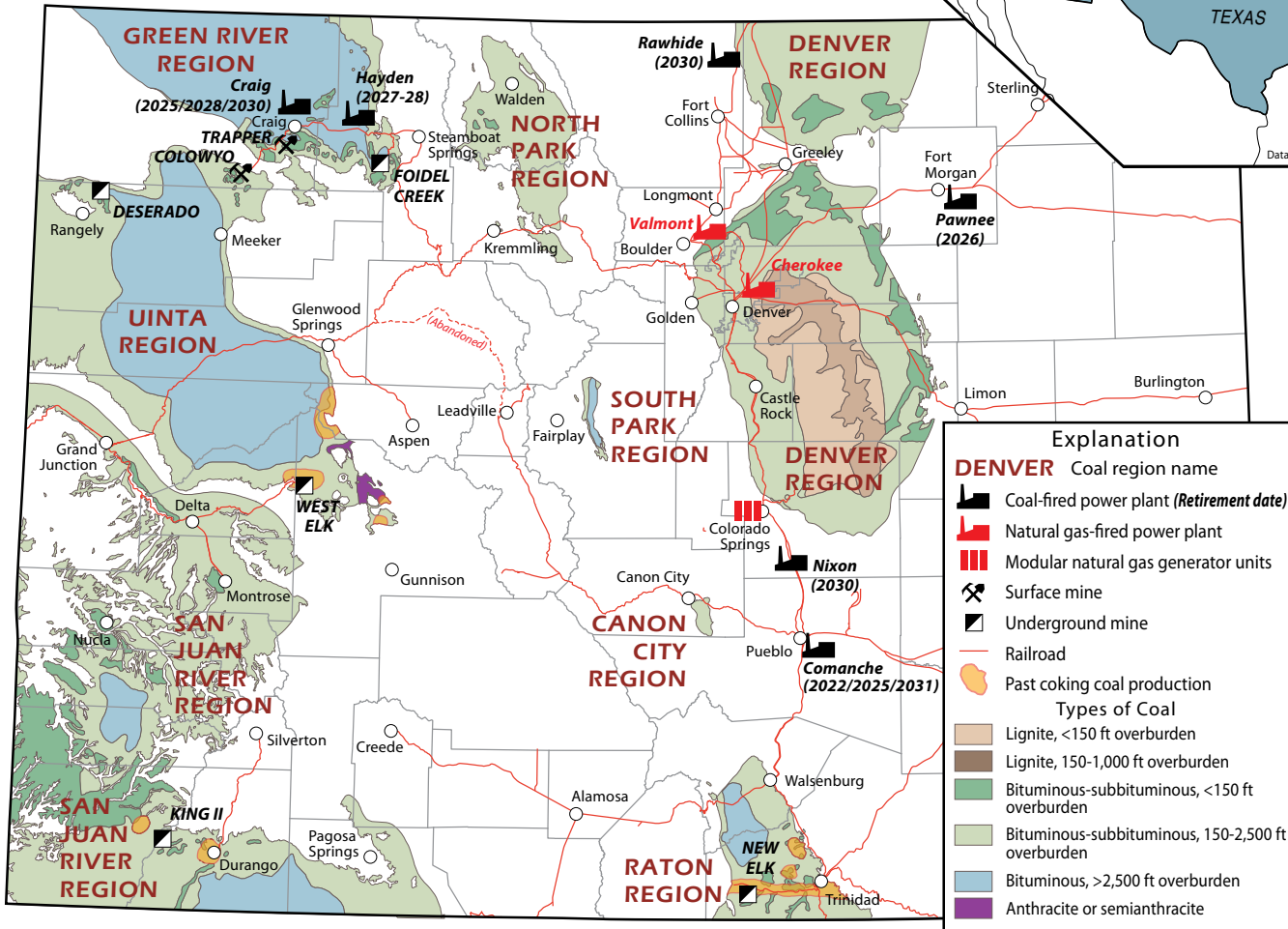


Figure 16. Locations of active coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2022. Dates in parentheses are estimated retirement dates for coal-burning units.

CONVENTIONAL ENERGY RESOURCES: URANIUM

According to the EIA, the total 2022 U.S. production of uranium was almost 10 times higher than 2021 but remained near all-time lows. Approximately 193,945 pounds of uranium concentrate was produced domestically in 2022 (EIA, 2023n). About 84% of the 2022 uranium production was from the White Mesa Mill, located in Utah, and less than 50 miles from the historic Uravan mineral belt in southwestern Colorado. The Uravan area was historically the largest uranium and vanadium producing mining area in Colorado. Although Colorado has been a producer of uranium in the past, there were no producing uranium mines or mills in 2022 within the state.

Most of the uranium purchased by U.S. civilian nuclear power reactors over the last several decades was imported from foreign countries. In 2022, 40.5 million pounds of triuranium octoxide was purchased by owners and operators of these nuclear power plants with ~94% purchased from foreign suppliers (EIA, 2023o). In 2022, most of the uranium delivered to U.S. civilian nuclear power reactors came from other countries including Canada (27%), Kazakhstan (25%), and Russia (12%). Although oil, natural gas, and coal imports from Russia were banned, uranium was not (EIA 2023p). According to the EIA (2023p), U.S. Congress established a strategic uranium stockpile of domestically produced uranium in 2020 that serves as backup supply for U.S. nuclear power plants. At the end of 2022, the DOE awarded the first U₃O₈ supply contracts for the reserve, including one to the White Mesa Mill in Utah.

In 2023, the DOE published a list of critical materials that included uranium. They classified uranium, as well as other materials, as “near critical” in the short term (2020 to 2025). A near critical classification indicates that the importance to energy is high but the short-term supply risk is lower than other materials. DOE short-term critical materials, with regards to their importance to energy and supply risk, included dysprosium, cobalt, gallium, graphite, iridium, neodymium, and terbium (DOE, 2023).

The weighted-average price reported by the EIA for uranium increased slightly from \$33.91 per pound in 2021 to \$39.08 per pound in 2022 (EIA, 2023o). Average spot prices of uranium in 2022 were about 49.81 per pound and increased to an average of about \$57.79 per pound through October 2023 (Cameco, 2023). **Figure 17** shows the average annual spot uranium prices in the U.S. since 2002. **Figure 18** shows the estimated annual production of uranium concentrate in the U.S. between 1996 and 2022.

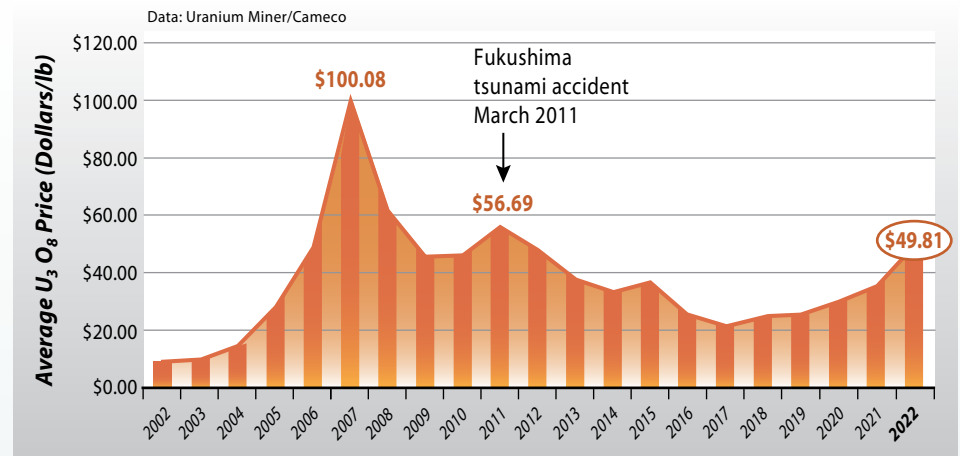


Figure 17. Average annual U₃O₈ price per pound in U. S., 2002–2022.

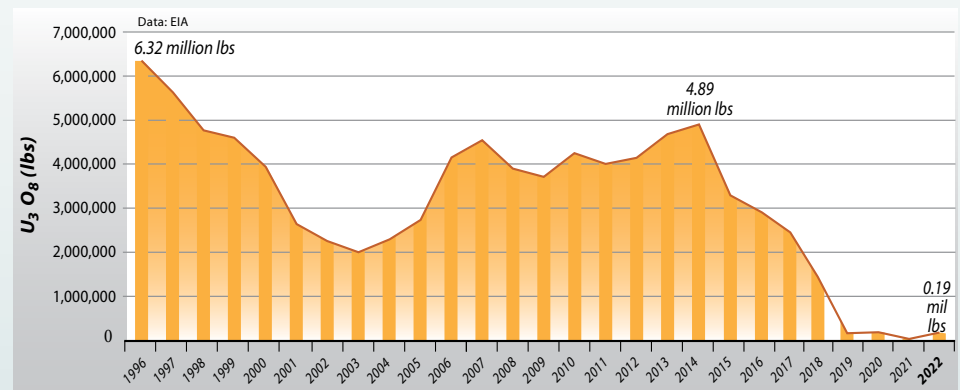


Figure 18. Annual production of uranium concentrate in U. S., 1996–2022.

NON-FUEL MINERAL RESOURCES

Non-fuel mineral resources include metals, industrial minerals, and construction materials (e.g., gold molybdenum, Portland cement, crushed rock, sand, and gravel). The total U.S. 2022 non-fuel mineral production value was estimated at \$98.2 billion, a ~8.6% increase from last year's estimated total of \$90.4 billion (USGS, 2023a). Colorado ranked 19th in U.S. non-fuel mineral production value and produced an estimated \$1.81 billion, or ~1.91% of the estimated total U.S. production value (USGS, 2023a). **Figure 19** shows the estimated non-fuel mineral production value in Colorado over time.

Metal Mining

Metals mined in Colorado include gold and molybdenum. The CGS estimates that the 2022 production value of gold and molybdenum in Colorado is ~\$804 million. This is ~7.9% lower than the estimated value of these two commodities in 2021 of ~\$873 million mainly due to the lower production of gold. Silver is also produced in Colorado and is a by-product of gold mining. Silver production values for Colorado were unavailable.

Molybdenum

Molybdenum is typically used in the production of engineering steels, stainless steel, molybdenum metal and other alloys. In 2022, according to the International Molybdenum Association (IMOA, 2023), about 87% of the world production

of new molybdenum (not recycled or remelted) was used in engineering steels, stainless steels, tool steels, foundries, and other metals and alloys. About 13% was used in chemical production (IMOA, 2023). The global production of molybdenum was ~551 million pounds in 2022 (USGS, 2023a). The top 2022 producers included: China (~220 million pounds), Chile (~97 million pounds), and the U.S. (~92.6 million pounds) (USGS, 2023a).

Colorado's annual production and the average annual price per pound for molybdenum trioxide (MoO_3) are shown in **Figure 20**. Estimated average prices increased from \$16.01 in 2021 to \$17.80 per pound in 2022 (USGS, 2023a). Most of the 2022 primary molybdenum production in the U.S. was from two Colorado mines that produced ~33 million pounds combined (Freeport, 2023a). In the U.S., Colorado ranked first in molybdenum production following by molybdenum recovered as a by-product of copper mining at Arizona mines (**Figure 21**).

Colorado hosts several known Climax-type porphyry molybdenum deposits. These are relatively rare deposit types found in the continental interior of western North America (Ludington and Plumlee, 2009). Freeport mines some of these deposits at their Climax and Henderson mines in Colorado. 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 21 million pounds in 2018, 17 million pounds in 2019, 14 million pounds in 2020, 18 million pounds in 2021, and 21 million pounds in 2022.

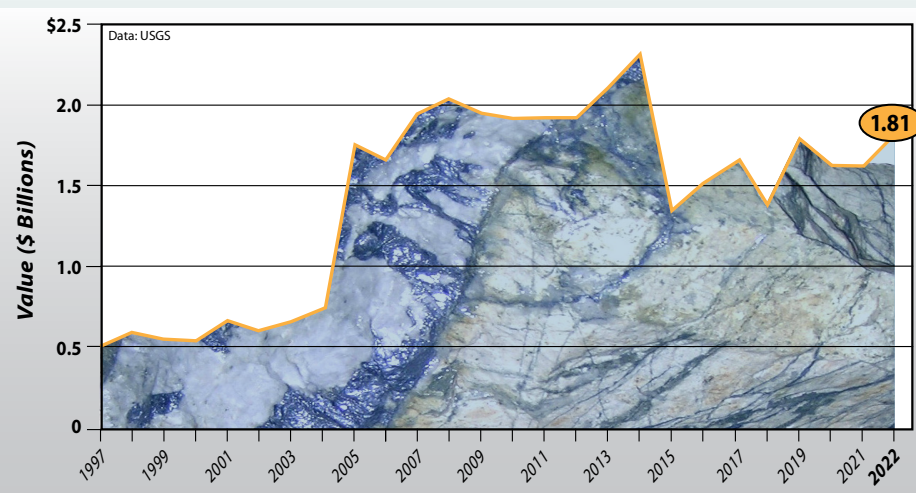


Figure 19. Total non-fuel mineral production value in Colorado, 1997–2022.

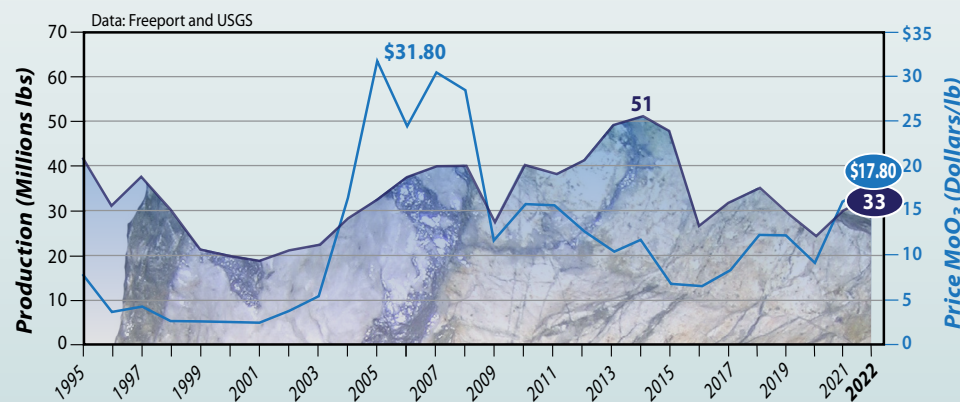


Figure 20. Molybdenum production in Colorado and average annual price 1995–2022.

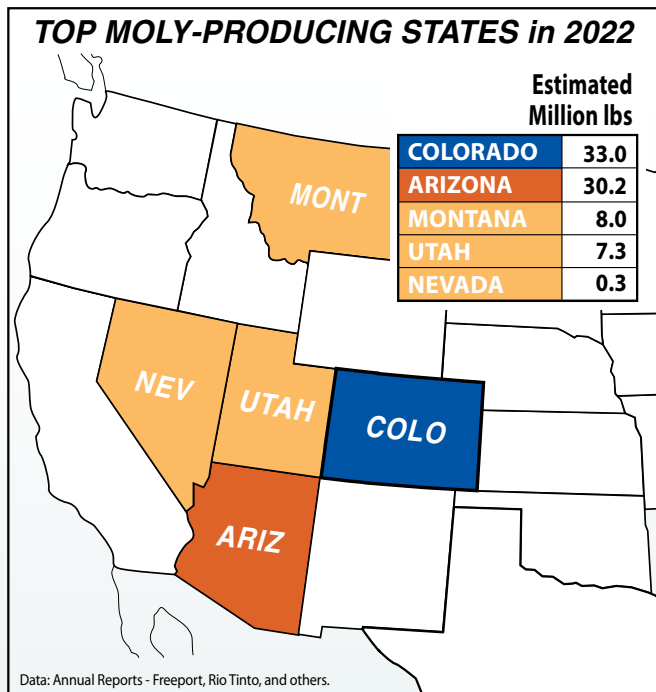


Figure 21. Top molybdenum producing states, 2022.

In 2022, Freeport also reported that the Climax Mine had 137 million metric tons of proven reserves at an average grade of 0.15% molybdenum and probable reserves of 15 million metric tons at an average grade of 0.10% (Freeport, 2023a).

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 14 million pounds in 2018, 12 million pounds in 2019, 10 million pounds in 2020, and 12 million pounds in both 2021 and 2022. In 2022, Freeport also reported that the Henderson Mine had 36 million metric tons of proven reserves at an average grade of 0.18% molybdenum and probable reserves of 15 million metric tons at an average grade of 0.12% (Freeport, 2023a).

Gold

U.S. gold mine production decreased from 187 metric tons (6.0 million troy ounces) in 2021 to an estimated 170 metric tons (5.47 million troy ounces) in 2022 with a value of ~\$9.84 billion based on average prices reported by the USGS (USGS, 2023a). In 2022, the U.S. was the fifth largest producer of

gold in the world following China (330 metric tons), Australia (320 tons), Russia (320 tons), and Canada (220 tons). World production of gold in 2022 was ~3,100 metric tons (~99.67 million ounces) (USGS, 2023a).

Figure 22 shows the price of gold and Colorado gold production from 1990 to 2022. In 2022, Colorado was the third largest producer of gold (182,000 ounces) in the U.S. (Figure 23) following Nevada (~4,044,977 ounces) and Alaska (~703,833 ounces). The average 2022 gold price remained about the same as 2021 at ~\$1,800 per ounce (USGS, 2023a).

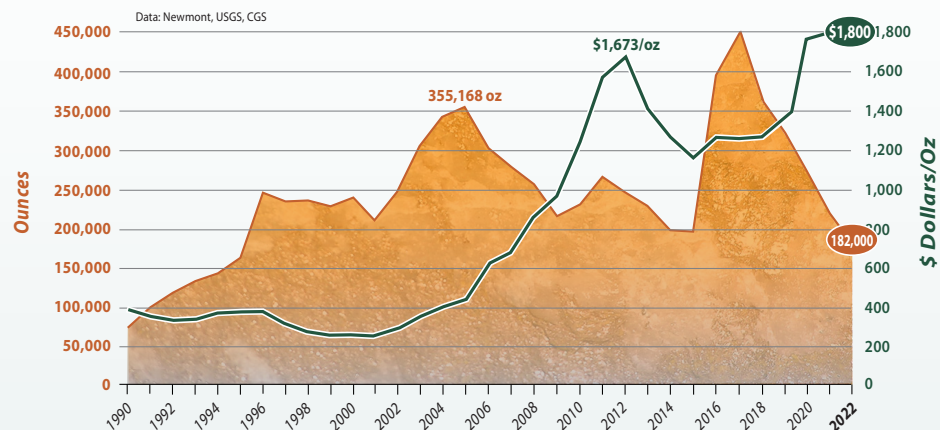


Figure 22. Colorado estimated gold production and average annual price per ounce, 1990–2022.

Gold production at Newmont Corporation's (Newmont) Cripple Creek and Victor (CC&V) open pit mine located in Teller County decreased from 220,000 ounces in 2021 to 182,000 ounces in 2022 (Newmont, 2023). 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. In 2023, Newmont completed their acquisition of Australia-based Newcrest Mining Limited expanding their gold and silver production as well as other commodities such as copper. Their corporate headquarters remain in Greenwood Village, Colorado. Newmont operates mines all over the world. In 2022, it was the largest producer of gold in the world (5.786 million ounces) (Businesswire, 2023; Newmont, 2023).

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 2022, one of the larger gold placer mines in Colorado was the Box Creek Placer Mine in Lake County (DRMS, 2023).

As of October 2022, there are currently 37 active mining permits with gold listed as the primary mined commodity in the Colorado Division of Reclamation, Mining and Safety (DRMS) database (DRMS, 2023).

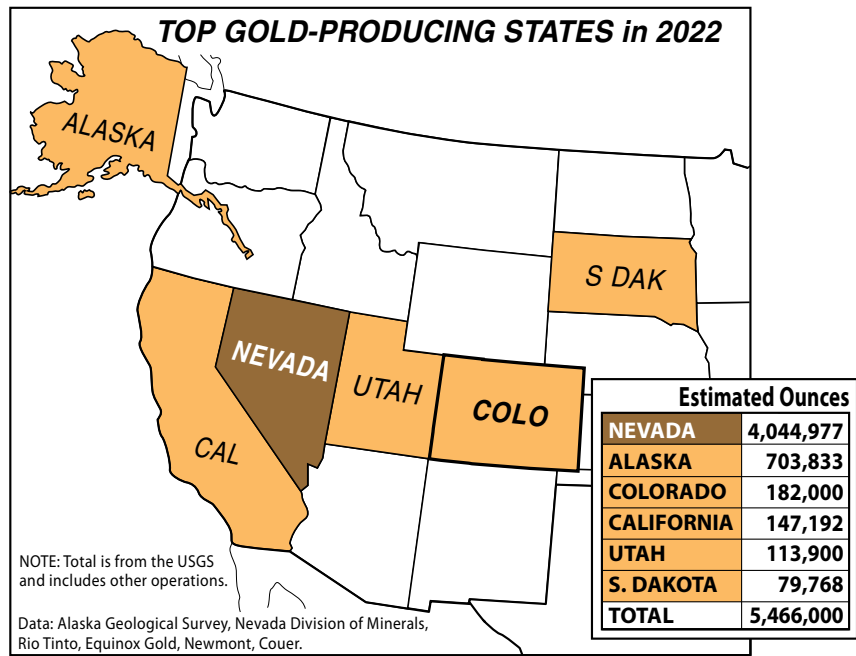


Figure 23. Major gold-producing states in 2022.

Other Exploration Activities

Worldwide exploration budget estimates for nonferrous metals increased ~16% from ~11.20 billion in 2021 to ~13.01 billion in 2023 (S&P, 2023). Most of this estimated total budget is for exploration targeting gold (53%), copper (21%), silver (4.8%), nickel (4.7%), lithium (3.6%), and other commodities such as lead, zinc, potash, platinum group elements, and cobalt (S&P, 2023). Lithium and nickel had the largest exploration budget increases from 2021. Worldwide exploration budgets are forecasted to decrease in 2023 (S&P, 2023).

Select exploration and development projects that have undergone recent activities are discussed below. Most of this information was compiled from company websites and available reports. Past CGS MEIA reports have additional information about these projects and updates associated with other properties.

Other mining operations/exploration projects in Colorado including the Bates Hunter Mine (GS Mining, 2023), Gold Links project (Dateline, 2023), Golden Wonder Mine, Klondike Mine, San Juan Silver Project (Hecla, 2023), Silver Cliff property (Viscount, 2023), and Tomichi porphyry deposit.

In 2023, Anfield Energy (Anfield, 2023a) completed a technical report on their uranium-vanadium Slickrock Property located in San Miguel County. Anfield’s website indicates, “a Slick Rock-attributed estimated inferred mineral resource of 7.7 million pounds of U₃O₈ with an average grade of 0.224%, along with 47.1 million pounds of V₂O₅ with an average grade of 1.35%.” The project encompasses an area of ~7.8 square miles in the Uravan mining area and the mineralization is within the Upper Jurassic Morrison Formation (Anfield, 2023a).

In 2023, Anfield Energy (Anfield, 2023a) also completed a technical report on their uranium-vanadium West Slope Project located in Montrose and San Miguel counties that covers ~6,913 acres. According to Anfield’s website, “These lands have a history of past uranium and vanadium production, with approximately 1.3 million pounds of uranium and 6.6 million pounds of vanadium extracted between 1977 and 2006. In 2007, Cotter Corporation commissioned Behre Dolbear to produce a Technical Report for the project. Based on available data and using a 0.05% uranium cut-off, Behre Dolbear estimated an in-place Measured Resource of 2.1 million tonnes of uranium at an average grade of 0.25%, equivalent to a total of 11 million pounds of uranium. Additionally, the report estimated an in-place Measured Resource of 1.2 million tonnes of vanadium at an average grade of 1.2%, totaling 53 million pounds of vanadium. In April 2022,a technical resource report related to four of the nine DOE leases which returned an Indicated uranium resource of 5.4 million pounds of uranium at an average grade of 0.197% and an inferred vanadium resource of 26.9 million pounds at an average grade of 0.984%.”

The La Plata mining district is in the La Plata Mountains located in La Plata and Montezuma counties. This area is located along the southwestern portion of the Colorado Mineral Belt and 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 (Cappa, 1998; Eckel, 1949). Mineralization in the area includes silver, gold, copper, and other commodities. Metallic Minerals Corp. (Metallic) continued their exploration of the Allard Stock area at their La Plata project and released an updated technical report in 2023 (Metallic, 2023). They continue to perform exploration activities at the property.

Silver North Resources Ltd (Silver North, formerly Alianza Minerals) continues to conduct exploration activities at their Twin Canyon project located east of Mancos, Colorado. According to Silver North, gold occurs in the Junction Creek Sandstone within the crest of an anticline capped by overlying Morrison Formation. Silver North indicates that the gold is associated with bitumen and

that the lack of high temperature alteration typical of gold systems suggests that the gold mineralization may be related to an oxidized petroleum system (Silver North, 2023).

Critical Minerals

As defined by the Energy Act of 2020 (<https://republicans-science.house.gov/2020/12/energy-act-of-2020>), critical minerals are defined as minerals, elements, substances, or materials that (Nassar and Fortier, 2021) “(i) are essential to the economic or national security of the United States; (ii) the supply chain of which is vulnerable to disruptions (including restrictions associated with foreign political risk, abrupt demand growth, military conflict, violent unrest, anti-competitive or protectionist behaviors, and other risks throughout the supply chain); and (iii) serve an essential function in the manufacturing of a product (including energy technology-, defense-, currency-, agriculture-, consumer electronics-, and healthcare-related applications), the absence of which would have significant consequences for the economic or national security of the United States.” Furthermore, critical minerals do not include fuel minerals (e.g., uranium) and other materials such as sand, gravel, stone, pumice, cinders, and clay.

The final 2022 critical mineral list (Federal Register [FR], 2022) includes: aluminum, antimony, arsenic, barite, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium. More information about this list is included in Nassar and Fortier (2022). In 2023, the DOE also published a critical materials list for energy that includes: aluminum, cobalt, copper, dysprosium, electrical steel, fluorine, gallium, iridium, lithium, magnesium, natural graphite, neodymium, nickel, platinum, praseodymium, silicon, silicon carbide and terbium (DOE, 2023).

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, copper, 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 2023, the USGS hosted five 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). The CGS is currently working on two geological mapping projects and two sampling programs associated with EarthMRI. For more on the U.S. Geological Survey EarthMRI program, see the EarthMRI home page: <https://www.usgs.gov/special-topics/earth-mri>. The USGS EarthMRI acquisitions interactive map viewer provides an overview of the current projects in Colorado and the entire U.S.: <https://ngmdb.usgs.gov/emri/#3/40/-96>. These projects include current CGS projects as well as geophysical surveys currently being conducted in Colorado.

AGGREGATE and INDUSTRIAL MINERALS

Sand, Gravel, and Crushed Stone

In 2022, the ~960 million tons of construction sand and gravel produced domestically was used primarily for Portland cement concrete aggregates (~42%), road base/coverings (~26%), construction fill (13%), and asphalt/other bituminous mixtures (~10%) (USGS, 2023a). Other uses include filtration, golf course maintenance, plaster and gunite sands, railroad ballast, roofing granules and snow and ice control (USGS, 2023a). In 2022, ~1,500 million tons of crushed stone (e.g., limestone, dolomite, granite, and other rock types) was produced domestically. This material was used primarily for construction aggregate (74%) (especially for road construction and maintenance), cement manufacturing (17%), lime manufacturing (5%), agricultural uses (1%), and for other uses (USGS, 2023a). DRMS currently lists over 850 active permits for sand, gravel, aggregate, and aggregate-related quarries in Colorado (DRMS, 2023).

Colorado quarry operators produced 51.4 million short tons of aggregate (sand, gravel, and crushed stone) in 2022 (USGS, 2023b) (**Figure 24**). Colorado was the ninth leading producer of construction sand and gravel in the U.S. (USGS, 2023b) and the estimated 2022 production value was \$368 million for sand and gravel and \$183 million for crushed stone. Average prices and production for sand and gravel and crushed stone are shown in **Figure 25** and **Figure 26**, respectively.

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.

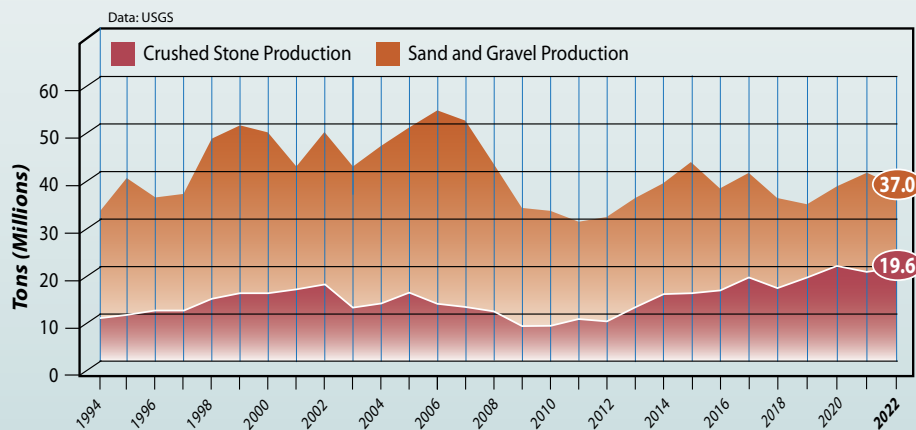


Figure 24. Aggregate production in Colorado, 1994–2022.

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; O’Keeffe and others, 2022).

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 2023 including: LafargeHolcim (US), Inc. (LafargeHolcim) in Florence, the GCC of America (GCC) plant in Pueblo, and CEMEX plant near Lyons. LafargeHolcim and GCC use 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 in the DJ Basin (Figure 1). Like the aggregate business, the production of cement is largely tied to the construction industry.

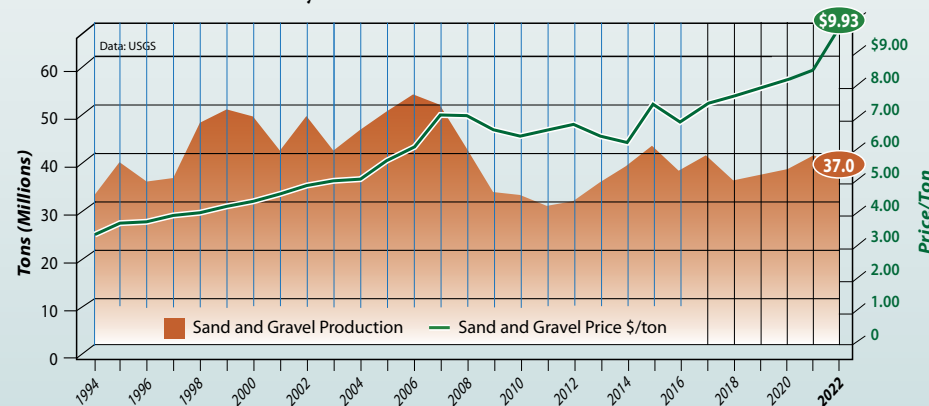


Figure 25. Price and production of sand and gravel aggregate in Colorado, 1994–2022 (sold or used by producers in the U.S.).

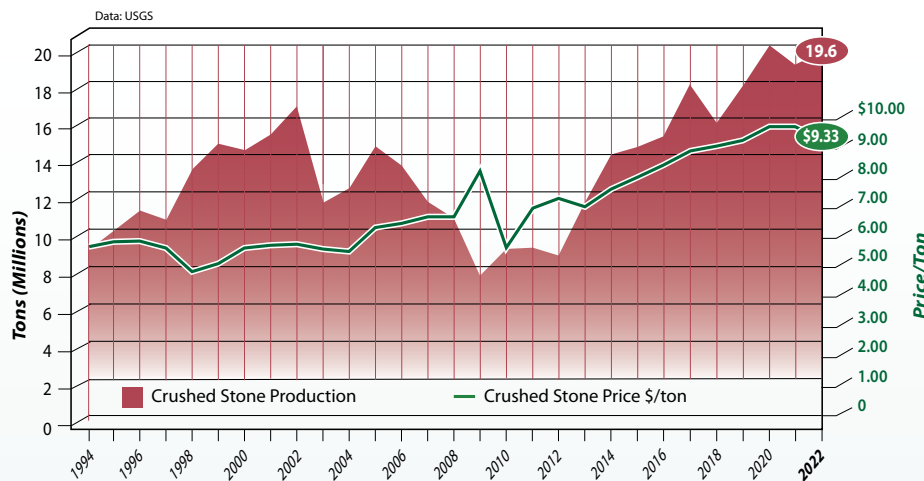


Figure 26. Price and production of crushed stone aggregate in Colorado, 1994–2022 (sold or used by producers in the U.S.).



Limestone in the Niobrara Formation near Lyons.

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 42 active permits for clay and 4 for shale in Colorado (DRMS, 2023). Two brick companies currently operate in the Denver

area: General Shale and Summit Brick Co. The Summit Brick Co. also operates a clay brick manufacturing facility in Pueblo. Common clay and shale production in Colorado was estimated at 297,000 short tons in 2017 and 293,000 tons in 2018 (O’Keeffe, 2023). The estimated average price of common clay was ~\$17.00 per ton in 2022 (USGS, 2023a):

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, 2023).

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 2022, domestic crude gypsum production was 21 million tons (USGS, 2023a). Information on gypsum production in Colorado is unavailable for proprietary reasons. There are currently 8 active mine permits associated with gypsum in Colorado (DRMS, 2023).

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, 2023). 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). Pete Lien & Sons mines gypsum for the cement industry and soil amendment from the Munroe Quarry north of Fort Collins in Larimer County (Lien, 2023). 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. Nahcolite is the naturally occurring mineral of sodium bicarbonate (NaHCO₃). 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 a 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’s production in 2019, 2020, 2021, 2022 was: 231,562; 238,266; 257,000; and 253,476 tons, respectively (**Figure 27**) (written communication, Natural Soda, 2023).

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. In 2022, Texas, Wisconsin, Indiana, and Vermont accounted for ~68% of U.S. production (USGS, 2023a). The rock types sold in the U.S. in 2022 by descending value included limestone (47%), granite (26%), sandstone (10%), marble (5%), slate (5%), and other miscellaneous stones (7%) (USGS, 2023a).

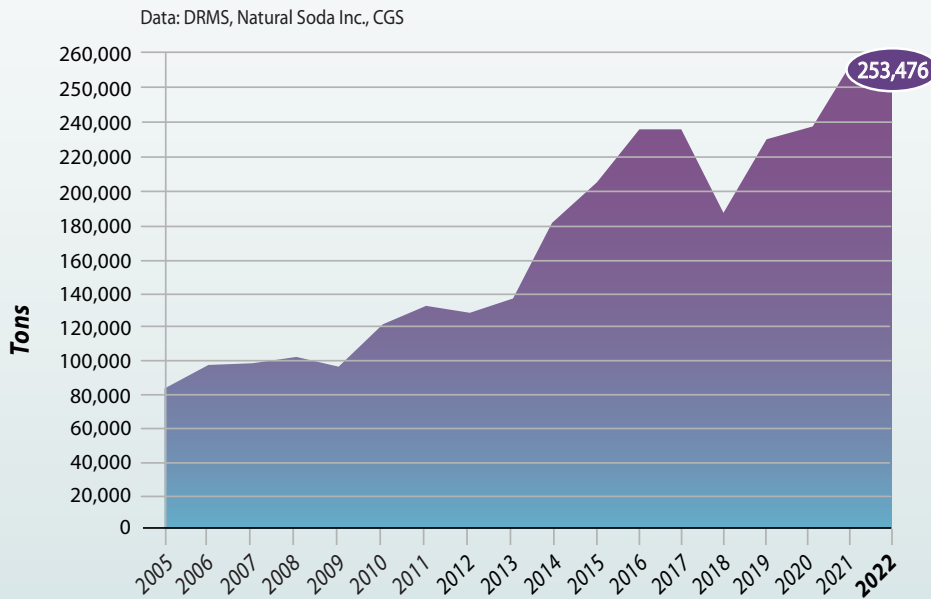


Figure 27. Estimated production of nahcolite in Colorado, 2005–2022.

INDUSTRIAL GASES (NON-ENERGY)

Carbon Dioxide

Naturally occurring carbon dioxide gas (CO₂) was produced in 2022 primarily from three areas in Colorado (in order of decreasing production volume): McElmo Dome in Montezuma County, Doe Canyon Deep in Dolores County, and Sheep Mountain Field in Huerfano County (ECMC, 2023a). The Ranglely Field (Rio Blanco County) and the McCallum Field (Jackson County) have also produced CO₂ in the past. Kinder Morgan's (KM) McElmo Dome, in operation since 1983, and the Doe Canyon Deep units are the largest producers in Colorado. About 92% of the 2022 production of CO₂ in Colorado was from Montezuma County (ECMC, 2023a). According to KM, McElmo Dome is one of the largest known pure CO₂ fields in the world and contains over 20 trillion cubic feet of CO₂ with ~5 trillion cubic feet of recoverable CO₂ remaining to be produced (KM, 2023). Most of the CO₂ is produced from the Mississippian Leadville Limestone at depths ranging from ~6,600 to 8,400 feet (Gerling, 1983). The source of the CO₂ is thought to be mainly from the "thermal decomposition of calcite in carbonate reservoirs in the area, predominantly the Leadville Limestone, during a period of elevated geothermal gradients in early to mid-Tertiary time" (Capp and Rice, 1995).

CO₂ is produced from wells in a similar way to natural gas production. Most of the CO₂ is used during enhanced oil recovery (EOR), also known as improved or tertiary recovery (as opposed to primary or secondary recovery), in Texas and New Mexico. EOR techniques are implemented to increase the extraction of crude oil from mature oil fields and residual oil zones (KM, 2023). CO₂ is used to extend the life of a well after the initial pressure in the well decreases. Other uses for CO₂ include welding gases, manufacture of dry ice, and in the food and beverage industry. In 2022, Colorado produced an estimated 307 billion cubic feet (Bcf) at an average calculated price of ~\$1.67 per thousand cubic feet (Mcf) and production value of ~\$514 million (ECMC, 2023a). **Figure 28** shows Colorado's estimated CO₂ production for the period 1994–2022.

Helium

In 2022, 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 (USGS, 2023a). The estimated price for private industry grade-A helium in 2022 was ~\$310 per Mcf (USGS, 2023a).

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. Tumbleweed Midstream LLC (Tumbleweed) operates the Ladder Creek Helium Plant and gathering system. The helium plant is located south of Cheyenne Wells in Cheyenne County. The gathering system includes ~730 miles of pipeline, located in both Colorado and Kansas, 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. The plant also produces natural gas liquids and residue gas (Tumbleweed, 2023).

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, 2023), Blue Star Helium Ltd. (Blue Star) continues to explore and develop their helium properties in Las Animas County. More information is available on their website (Blue Star, 2023).

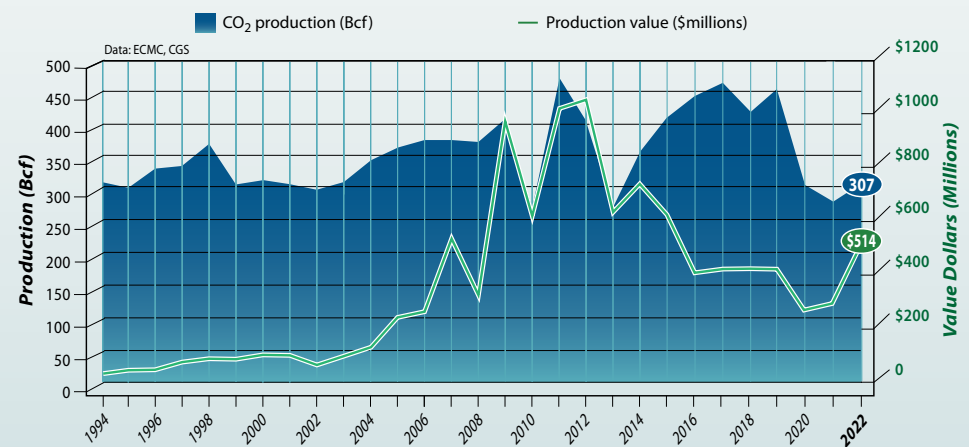


Figure 28. CO₂ production and estimated production value, 1994–2022.

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