

INFORMATION SERIES 84

Colorado Mineral and Energy Industry Activities 2020-2021

by Michael K. O'Keeffe



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Cover: Haul trucks await the work day at the LaFarge-Holcim plant near Florence, CO. Photo credit: Larry Scott for the CGS.

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EXECUTIVE SUMMARY and TAX REVENUE

The Colorado Geological Survey (CGS) estimates the total value of 2020 mineral and energy fuels production in Colorado to be \$12.07 billion, lower than the 2019 estimate of \$18.02 billion. In 2020, the top commodities produced in terms of production value include: oil, natural gas, gold, coal, sand and gravel, cement, industrial gases (carbon dioxide and helium), molybdenum, and crushed stone. Estimated mineral production values for 2020 are shown by commodity type in **Figure ES-1**. Oil and natural gas production accounted for ~80.7% of Colorado's total mineral and energy production value in 2020. Estimated mineral and energy production values for 1994 through 2020 are shown in **Figure ES-2**.

The total estimated value of Colorado oil and natural gas production in 2020 is \$9.74 billion. Although 2020 oil production decreased in Colorado, oil and

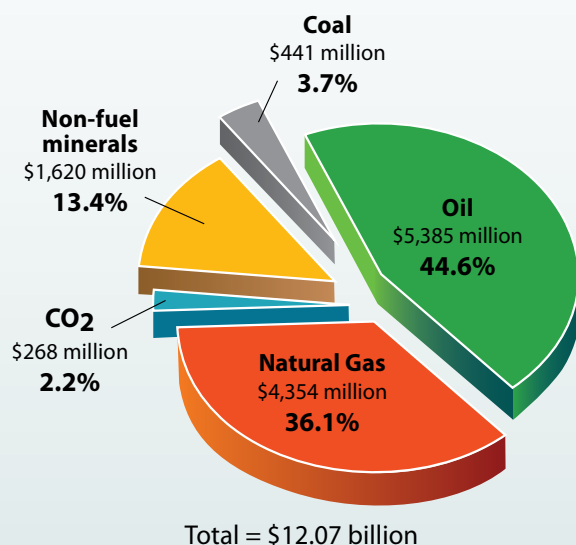


Figure ES-1. 2020 Colorado mineral production value by commodity type (U. S. dollars).

natural gas production remains higher than historical values and production values have increased from 2016 due to slightly higher prices and an increase in demand. Colorado has the seventh largest proven natural gas reserves and eighth largest proven oil reserves in the U.S. (EIA, 2021a). The estimated value of Colorado coal production in 2020 is \$441 million. The overall decreasing trend in coal production is due primarily to the increased use of natural gas and renewable energy resources nationwide. Colorado dropped from the 11th largest coal producer in the U.S. in 2018 to the 13th largest producer in 2020

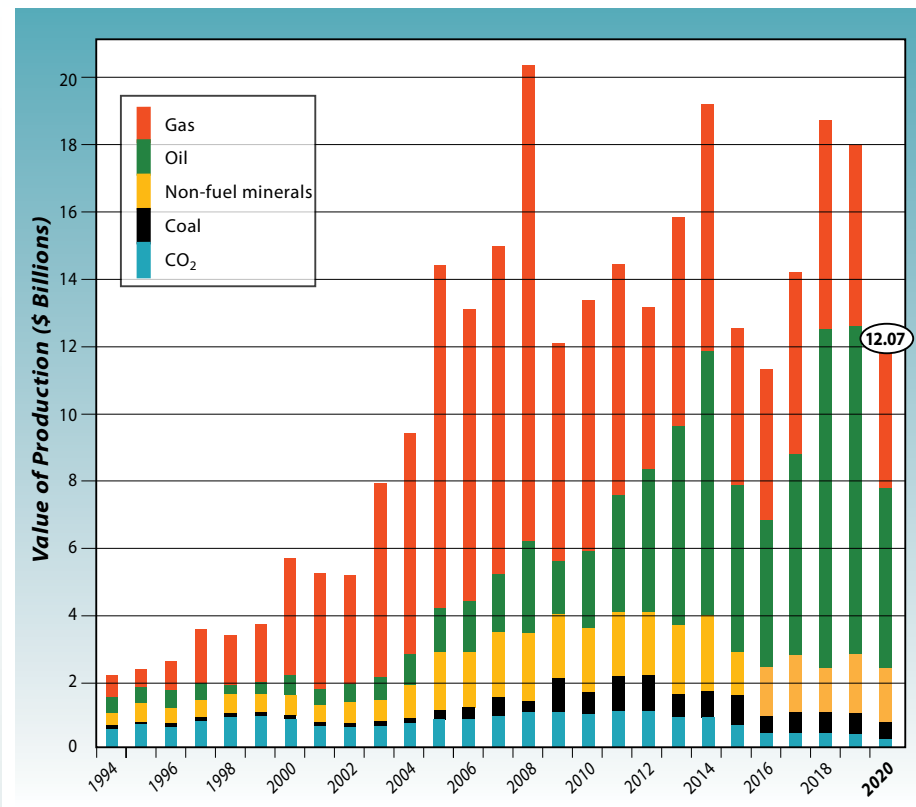


Figure ES-2. Mineral and energy fuel production value in Colorado, 1994–2020.

(EIA, 2021b) 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 2020 is \$1.62 billion (USGS, 2021a). Colorado is the third largest gold producer in the U.S., behind Nevada and Alaska, based on the total 2020 production from a single mine. Two Colorado mines continue to produce molybdenum and the state was the third largest producer of this metal in 2020 behind Utah and Arizona. Although Colorado has been a producer in the past, there was no uranium mine production in Colorado in 2020, however, several property leasing and exploration activities continued in 2020 and 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 2020 is \$268 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 Department of Local Affairs (DOLA) administers the distribution of severance tax revenue to county and local governments. In fiscal

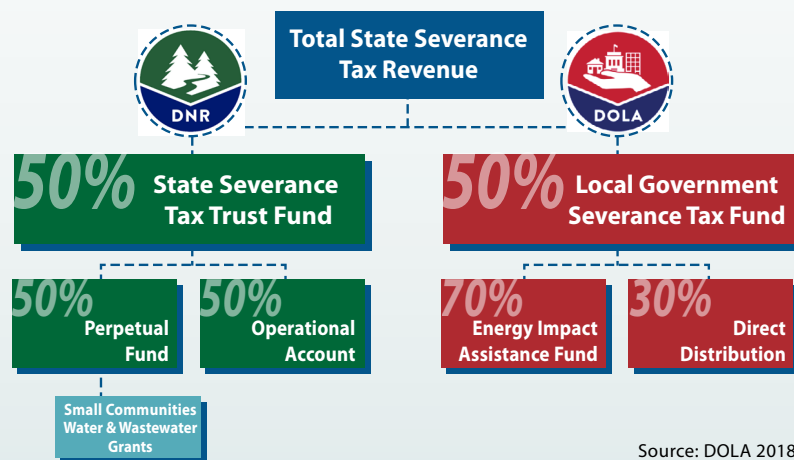


Figure ES-3. Distribution of state severance tax revenue in Colorado.

year (FY) 2019/2020 (19/20), July 1st through June 30th, Colorado collected ~\$147.9 million in severance taxes from metal, coal, and oil and gas producers. **Figure ES-4** shows the annual severance taxes collected since 1994. Several factors caused low levels of severance tax collections during FY 16/17 including the ad valorem tax credit and amended tax returns filed in 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). During 19/20, Colorado was required to refund more oil and gas severance taxes than it collected (DOLA, 2021) which resulted in a decrease of distributions of over 96%

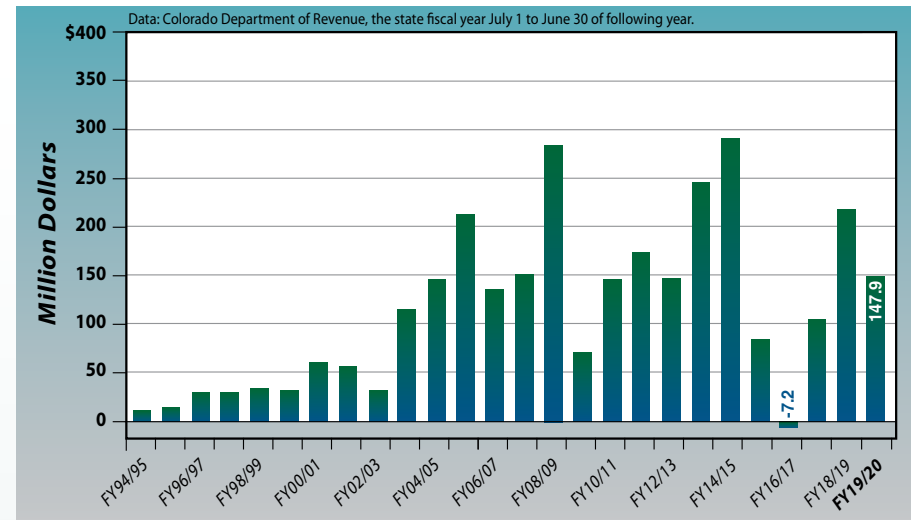


Figure ES-4. Colorado net severance tax collections FY94/95-FY19/20 (NOTE: In FY16/17, severance refunds exceeded collections, hence the negative value).

from last year (DOLA, 2021). The map in **Figure ES-5** shows the distribution of severance taxes to each county. Projections by the Colorado Legislative Council and Office of State Planning and Budgeting indicate that future severance tax collections will recover somewhat before the 2022 direct distribution (DOLA, 2021).

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). 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 19/20, SLB trust assets are valued at \$4 billion. State trust lands generated ~\$140.3 million in gross revenue (SLB, 2021a). 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 19/20, the SLB provided \$78.5 million to the BEST program and \$61.5 million to the Public School Permanent Fund managed by the Colorado State Treasurer which provides funding for the Department of Education as well as additional funding for the BEST program (SLB, 2021a). In FY 19/20, the SLB received ~\$113.21 million in mineral revenue (SLB, 2021b). The revenues consisted of the following: oil and natural gas royalties and rentals, \$108.9 million; coal, \$346,000; other minerals, \$2.5 million; and other revenues, \$1.5 million (SLB, 2021b). **Figure ES-6** shows the SLB revenues from FY 96/97 to FY19/20.

Severance Tax Distribution by County

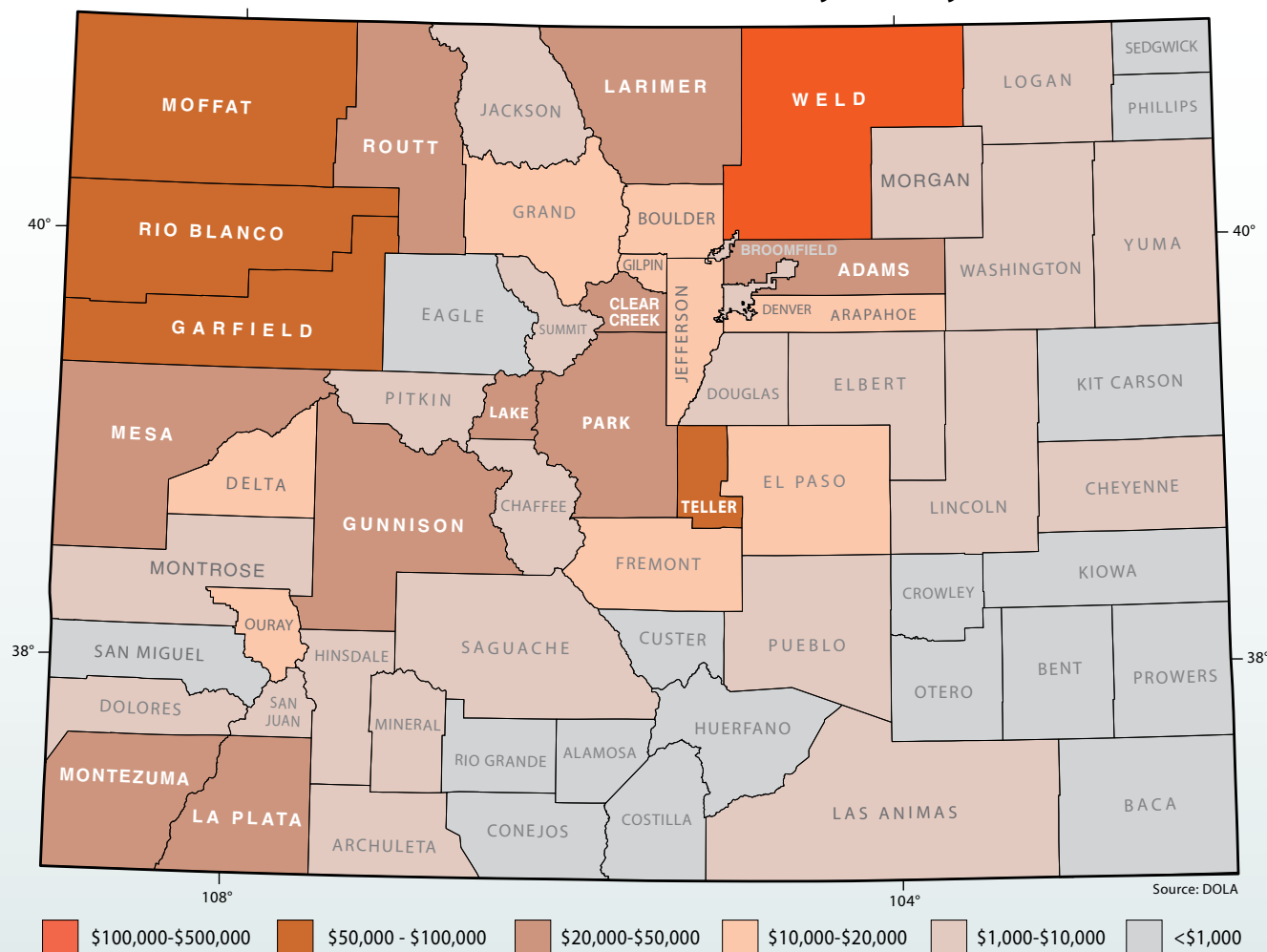


Figure ES-5. Colorado mineral severance tax distributions by county, FY 19/20.

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 2020, federal mineral lease revenues generated totaled ~\$114 million with ~\$57 million disbursed back to the state (U.S. Department of

Revenue [USDR], 2021). **Figure ES-7** shows the revenue from federal mineral leases from 2009 to 2020.

On March 11, 2020, the World Health Organization (WHO) declared the novel coronavirus (COVID-19) a global pandemic (Cucinotta and Vanelli, 2020). The long-term impact of the global pandemic on commodities generated in Colorado has yet to be determined. When compared to the 2019 production data (O'Keeffe and Berry, 2021), the 2020 production of coal, gold, molybdenum, natural gas, and oil in Colorado changed by about -22%, -16%, -17%, +1.4%, and -11%, respectively

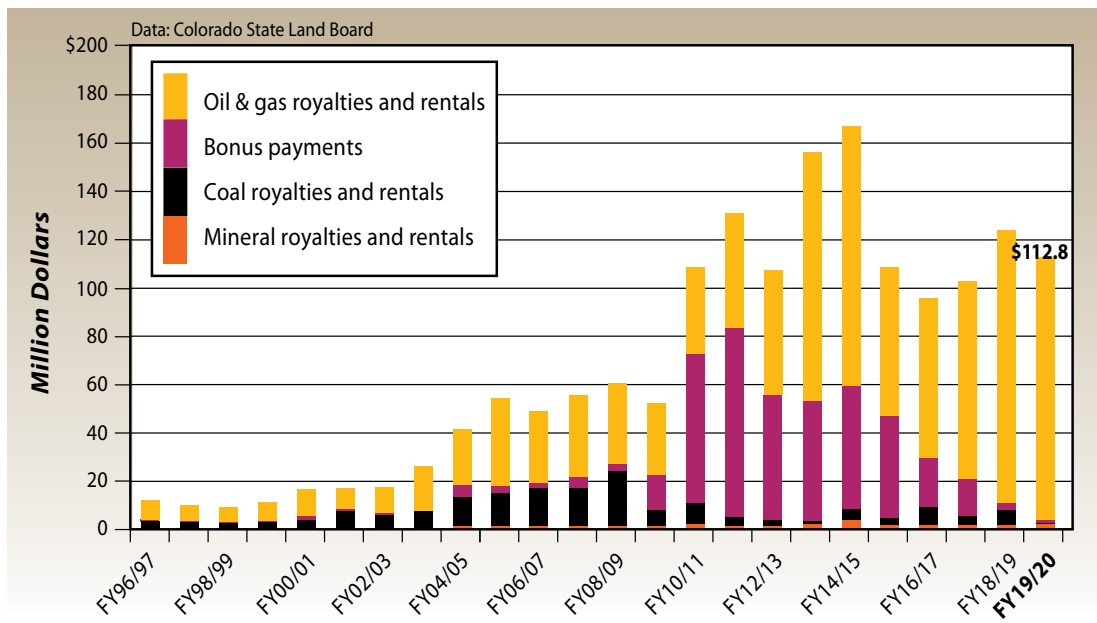


Figure ES-6. Colorado State Land Board (SLB) mineral revenues.

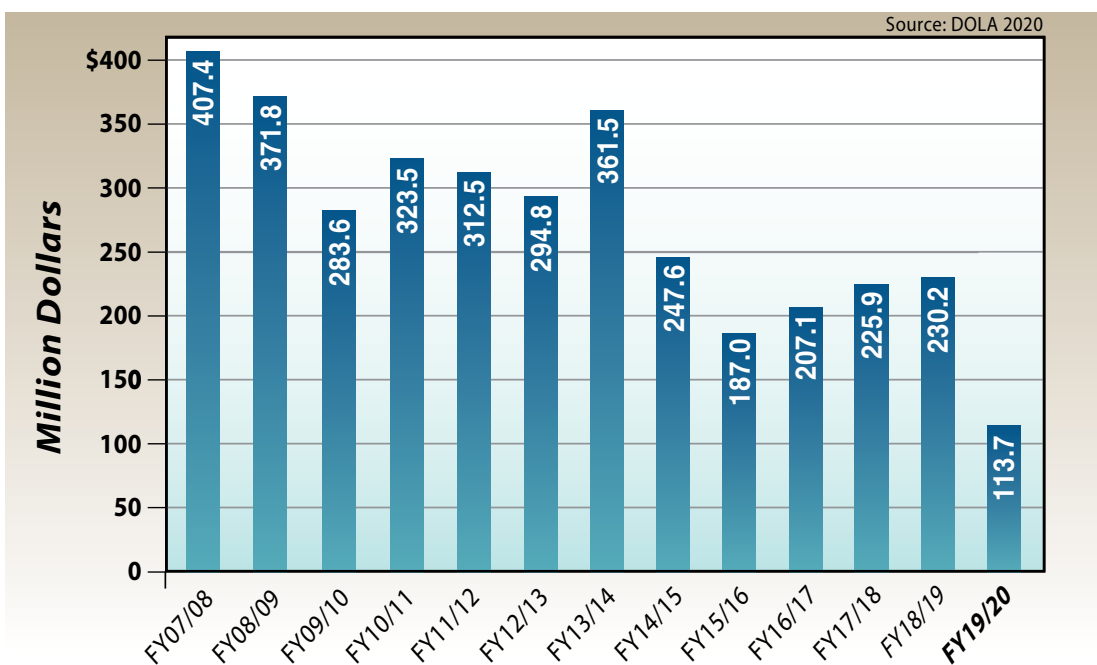


Figure ES-7. Federal mineral lease revenue generated in Colorado.

(DRMS, 2021a; Newmont, 2021; Freeport, 2021a; COGCC, 2021a). Some of these production decreases were due directly to COVID-19.

For example, Freeport McMoRan Inc. (Freeport) reduced molybdenum production in 2020 at the Climax Mine by ~50% in response to COVID-19 (Freeport, 2021a). In October 2021, Freeport reported that production at the Climax Mine was back to pre-COVID-19 levels (Freeport, 2021b). Oil production decreased due to a reduction in oil demand brought on by COVID-19 which restricted travel and closed businesses globally (IEA, 2021; FERC, 2021). However, other factors caused the decrease in Colorado gold production from Cripple Creek & Victor, the only major gold mine in Colorado, including leach recovery timing and lower grades milled (Newmont, 2021).



CONVENTIONAL ENERGY RESOURCES: PETROLEUM

Oil and 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 2020 oil and natural gas approved drilling permits (COGCC, 2021b). According to the U.S. Department of Energy (DOE) Energy Information Agency (EIA), ~2.70 billion barrels of crude oil, ~65% of total U.S. crude oil production in 2020 compared to ~63% in 2019, was produced from tight oil formations (EIA, 2021c). Hydraulic fracturing and horizontal drilling techniques allow relatively cheap production from unconventional reservoirs.

Due to efforts to mitigate the spread of COVID-19, oil demand decreased in 2020 driving oil prices down (FERC, 2021). Average annual oil prices decreased drastically in 2020 to \$31.40 per barrel (EIA Colorado Domestic Crude Oil First Purchase Price) from an average of \$50.89 in 2019 (EIA, 2021d). Using this price and the Colorado Oil and Gas Commission (COGCC) production estimate

Oil & Gas Well Drilling Permits in Colorado

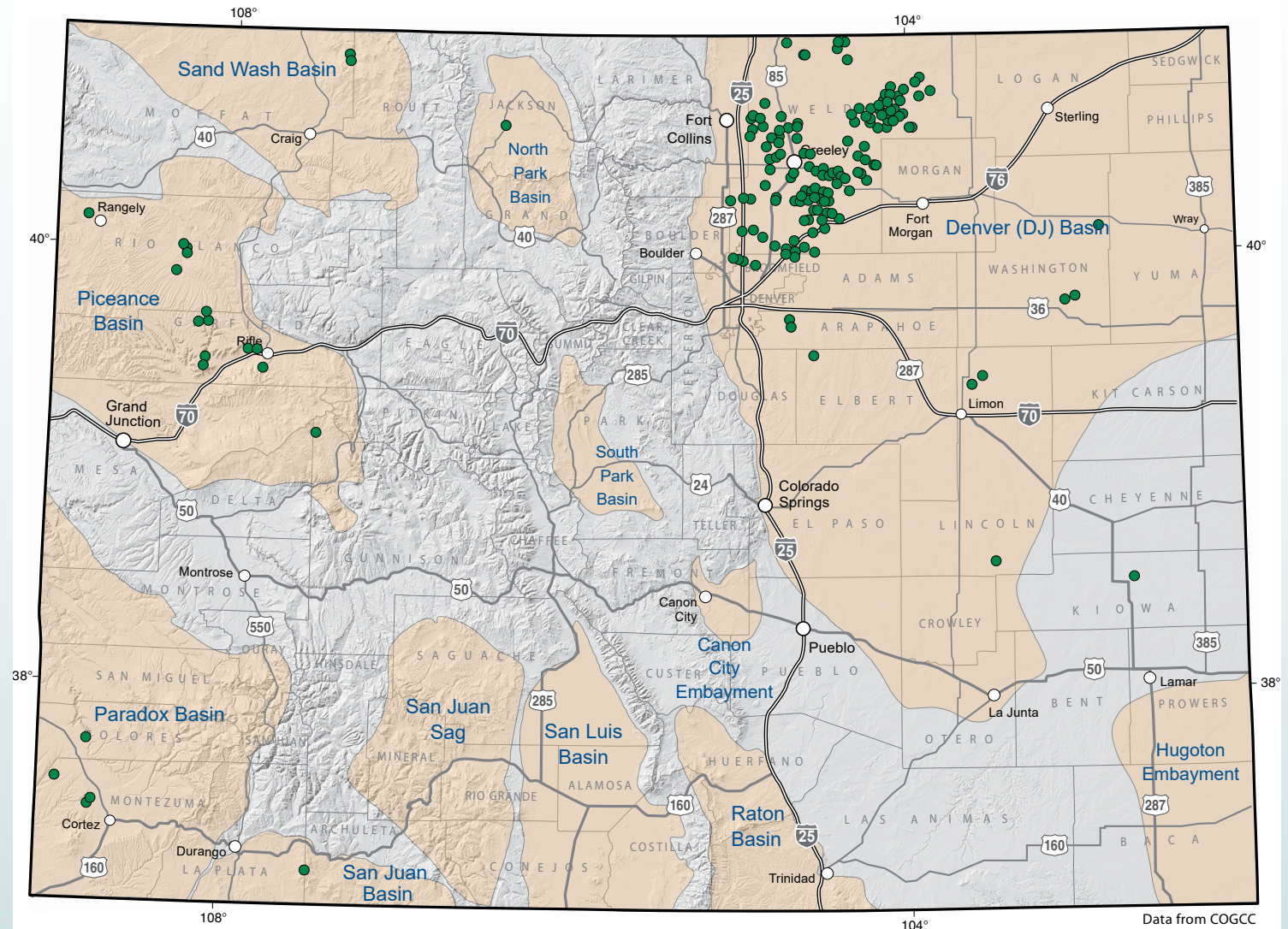


Figure 1. Sedimentary basins and the location of oil and gas well drilling permits (green dots) approved January 2020 to December 2020.

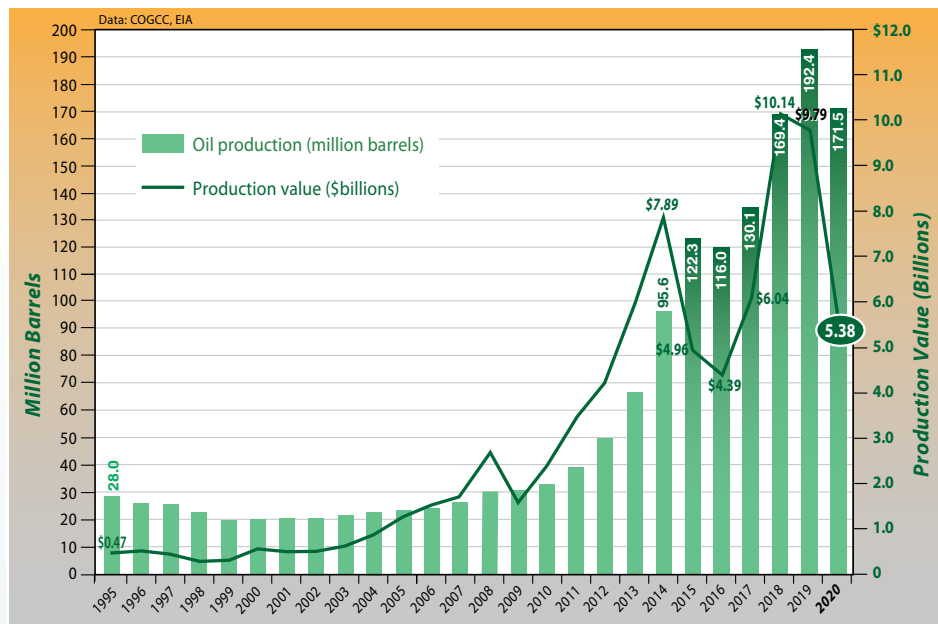


Figure 2. Oil production and estimated production value in Colorado, 1995–2020.

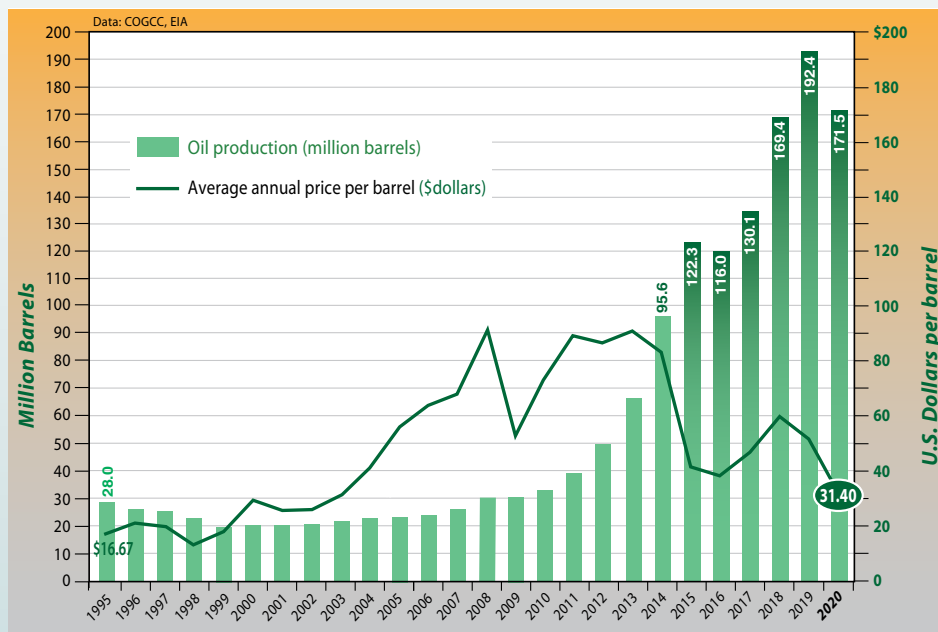


Figure 3. Colorado oil production and average annual price per barrel, 1995–2020.

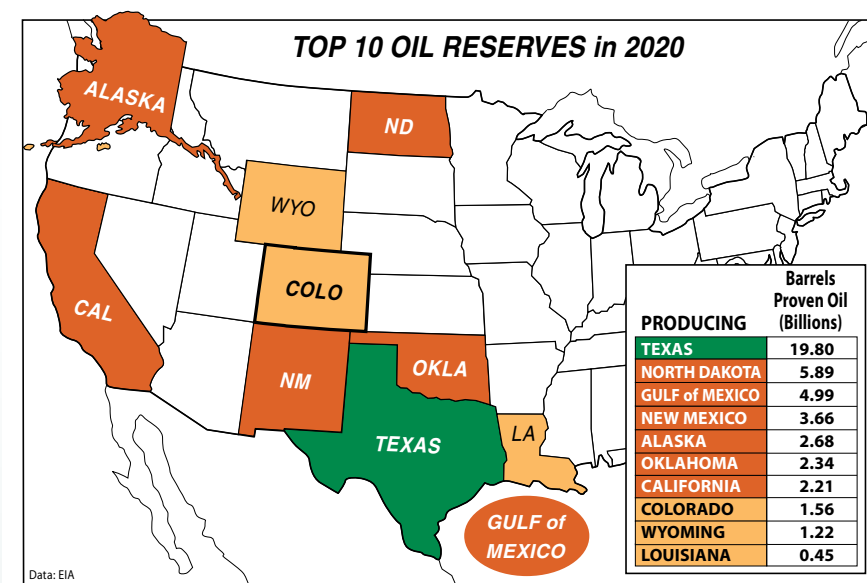


Figure 4. Top 10 states with proven oil reserves in 2020.

(COGCC, 2021a), the estimated overall oil production value in 2020 for Colorado is \$5.385 billion, a decrease of ~45% when compared to the 2019 estimated oil production value of \$9.793 billion (**Figure 2**) (O’Keeffe and Berry, 2021). The 2020 total oil production is the second highest on record (last year was the highest on record), however, oil production values decreased due to the dramatic decrease in price. Estimated oil production in Colorado between 2019 and 2020 decreased by over 20 million barrels to ~171.5 million barrels. Oil production in Colorado and the average annual price per barrel over time are shown in **Figure 3**. At the end of 2020, Colorado ranked eighth among the top ten states with estimated proven oil reserves of ~1.557 billion barrels of oil (BO) (**Figure 4**). Texas ranked first with estimated proven oil reserves of 19.796 BO (EIA, 2021e).

The 2020 average spot price for natural gas was \$2.11 per thousand cubic feet (Mcf) (based on a heat content of 1.039 British Thermal Units per Mcf) (EIA, 2021f) (**Figure 5**). This is the lowest natural gas average spot price recorded in at least the last 23 years. Although 2020 natural gas prices were low, annual U.S. natural gas demand and production were similar to 2019 (FERC, 2021). U.S. natural gas production generally increased between 2008 and 2020 which is consistent with the general decrease in price. Colorado’s natural gas production increased from ~2,035 billion cubic feet (Bcf) in 2019 to ~2,064 Bcf in 2020. The estimated total 2020 natural gas production value in Colorado, using the Henry Hub spot price (EIA, 2021f) and COGCC production data (COGCC, 2021a), is \$4.35 billion.

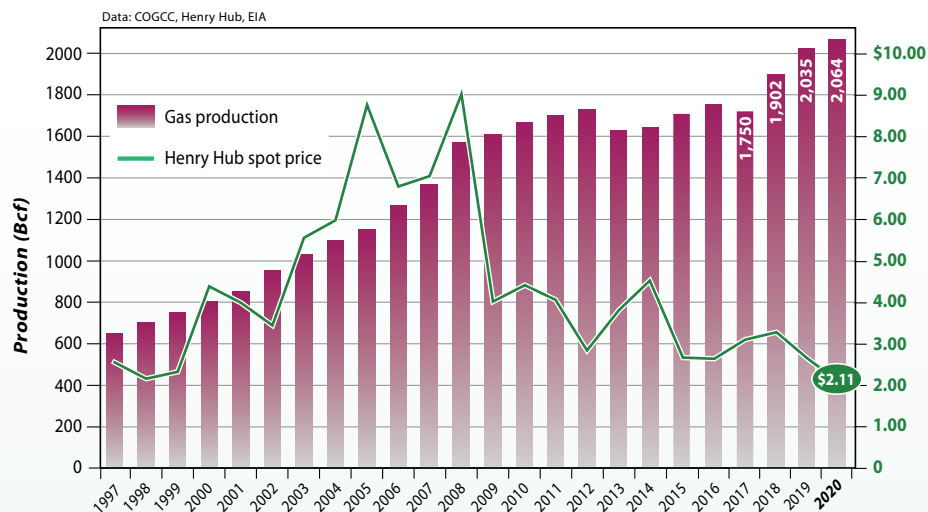


Figure 5. Colorado natural gas production and average price, 1997-2020.

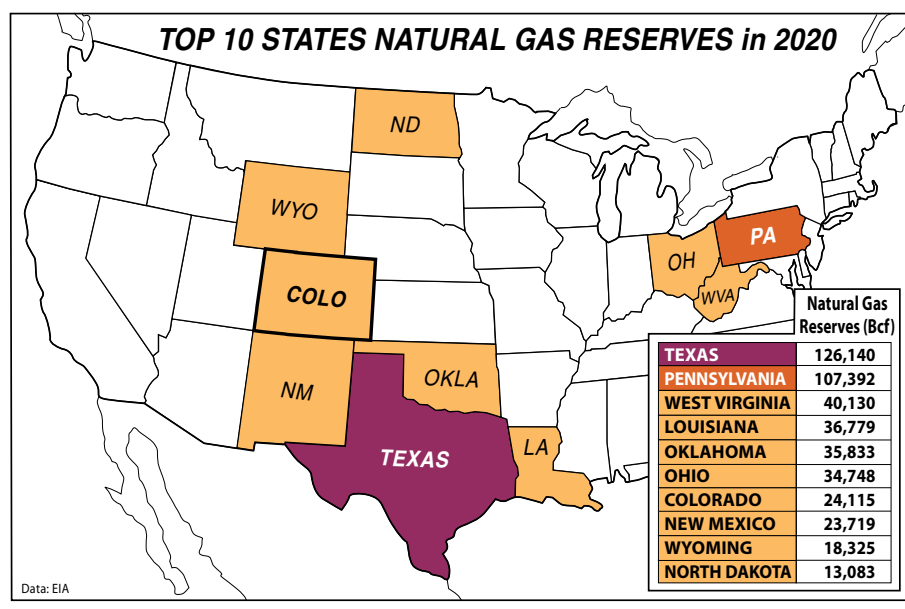


Figure 6. Top 10 states with proven natural gas reserves in 2020 (years end).

This is a decrease of about 20% compared to the 2019 estimated natural gas production value of \$5.41 billion (O’Keeffe and Berry, 2021). At the end of 2019, Colorado had proven natural gas resources of 24,115 Bcf, which was the seventh largest in the U.S. (EIA, 2021e) (**Figure 6**).

As presented in earlier CGS MEIA reports, the U.S. Geological Survey (USGS) released an updated Mancos Shale oil and gas potential assessment for the Piceance Basin located in central and northwestern Colorado (USGS, 2016). This study 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).

The House Natural Resources Committee held a hearing in 2018 to discuss the possibility of exporting natural gas from the Piceance Basin through the proposed Jordan Cove Liquefied Natural Gas (LNG) Terminal and Pacific Connector Gas Pipeline. This project would connect the resources from the Piceance Basin via pipeline to international markets through a proposed LNG export terminal in Oregon. In 2020, the Federal Energy Regulatory Commission authorized the construction of the Jordan Cove LNG Terminal in Oregon and the related Pacific Connector Gas Pipeline (DOE, 2020a), which, if built, would transport natural gas from Colorado to the terminal and overseas markets. However, in late 2021, the developer of the Jordan Cove LNG Terminal and associated pipeline said the company would not move forward with the project due to challenges obtaining the necessary state permits and other external obstacles (E&E News, 2021).

Coalbed Methane

Figure 7 shows Colorado's annual coalbed methane (CBM) production versus conventional natural gas over time. CBM production in Colorado reached its highest levels, 59%, of the total natural gas production during 1998 and has continuously declined to ~11% of the total natural gas production (224 Bcf) in 2020 (COGCC, 2021a). 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

Thirty-six of Colorado's 64 counties produced crude oil and/or natural gas in 2020. 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 2019 "Colorado First Purchase" price of \$31.40 per BO for the average annual price of oil (EIA, 2021d) and the average spot price for natural gas of \$2.11 per Mcf (EIA, 2021f). The total 2020 estimated oil and natural gas production value for Colorado is \$9.739 billion. **Figure 8** shows the estimated total oil and natural gas production value by county.

Weld County is the single largest producer of oil and natural gas in Colorado with an estimated total production value of ~\$6.35 billion. Garfield County has the second largest natural gas and oil production value with an estimated total of \$933 million. La Plata County ranks third in natural gas and oil production value with an estimated total of \$466 million. Rio Blanco, Adams, and Broomfield counties have a combined oil and natural gas production value of \$708 million. **Figures 9 and 10** show the estimated oil and natural gas production by county for 2020, respectively.

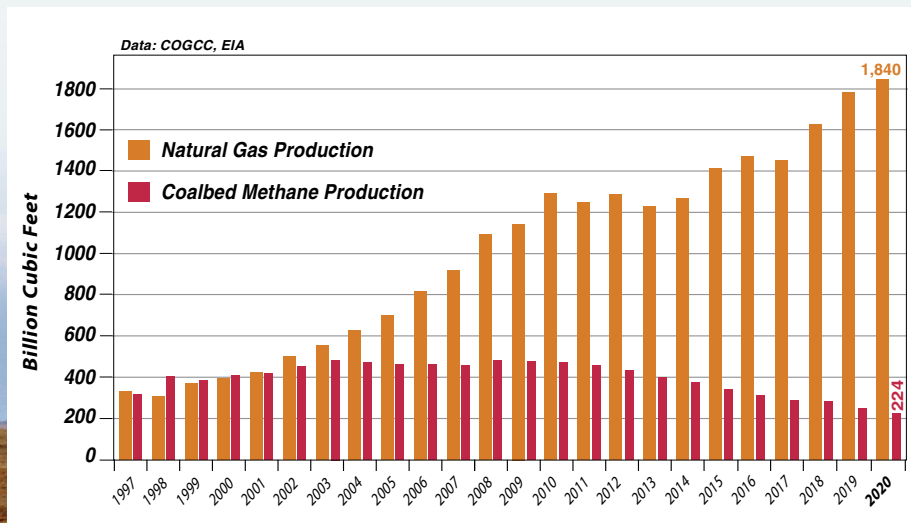
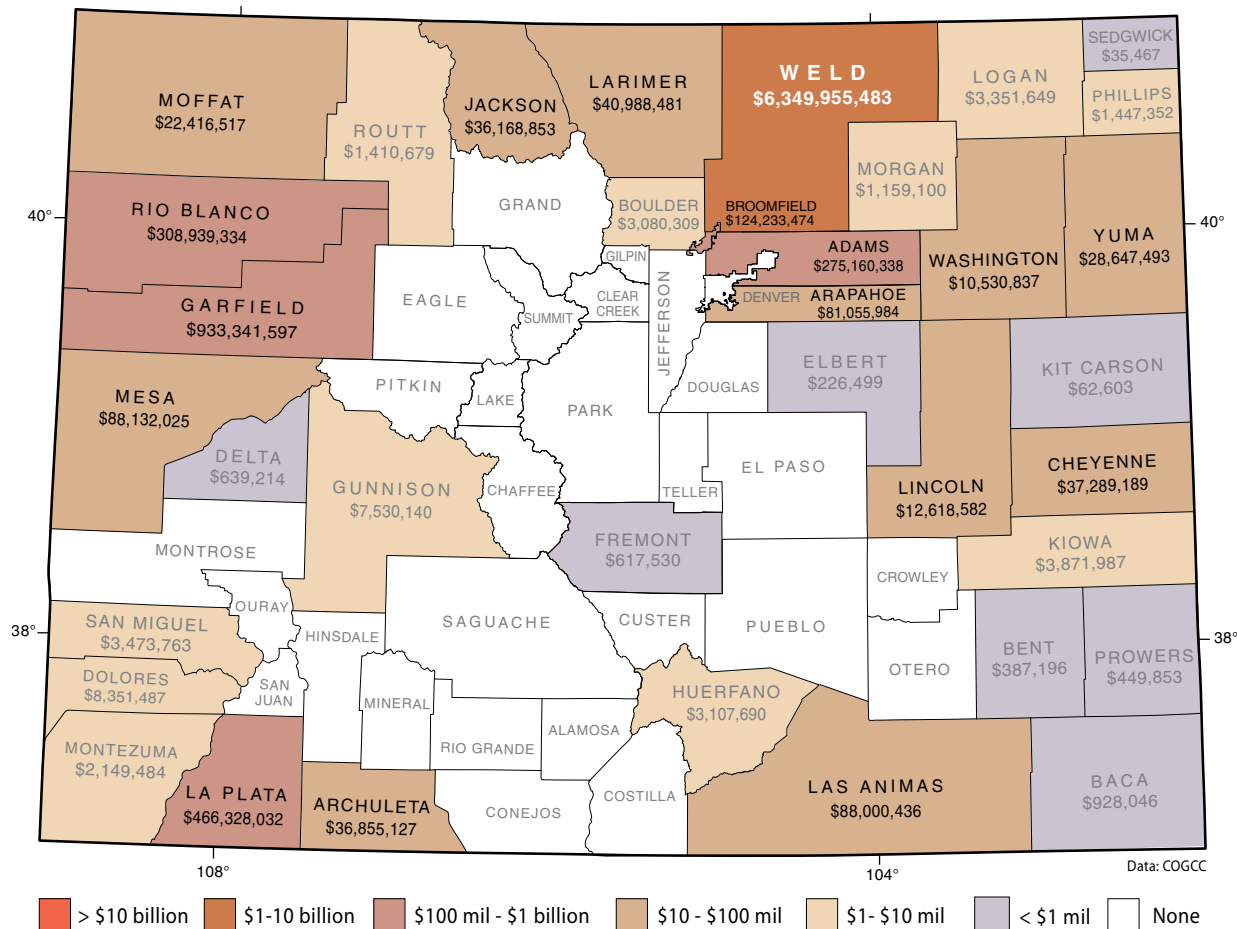


Figure 7. Coalbed methane vs. non-coalbed natural gas production in Colorado, 1997-2020.



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 approved 1,336 drilling permits in 2020 (COGCC, 2021c), a 74% decrease from 2018 and 34% decrease from 2019, likely due to decreasing prices and uncertainty associated with COVID-19. **Figure 11** shows the number of annual oil and natural gas drilling permits in Colorado from 1994 to 2020.

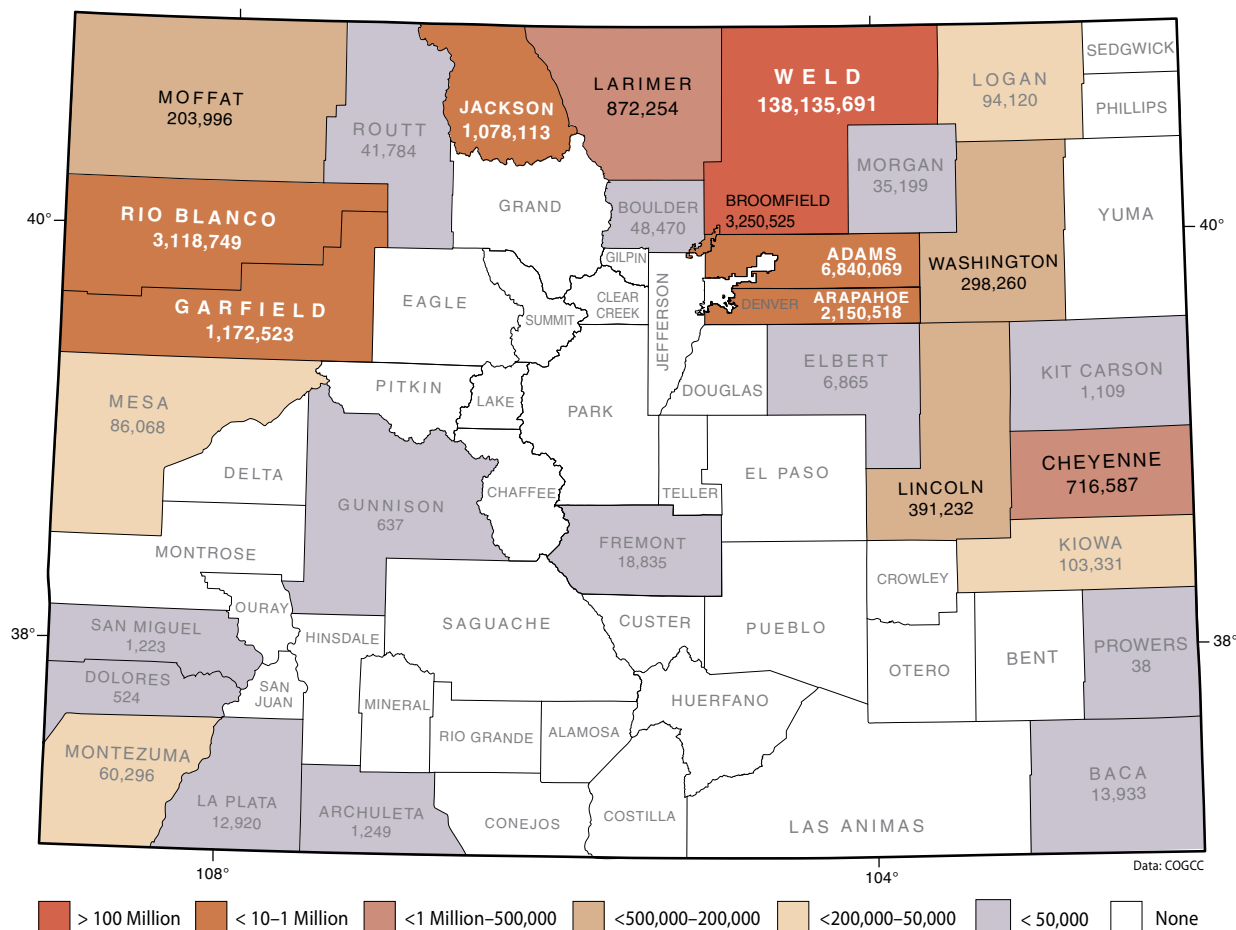
Oil Shale

As reported previously (O’Keeffe and Berry, 2021), more than half of the world’s known oil shale resources are in the Eocene Green River Formation, which covers ~16,000 acres in the Green River Basin in Wyoming, the Piceance Basin in Colorado, and the Uinta Basin in Utah. 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 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).

Figure 8. Estimated oil and natural gas production value by county in Colorado, 2020.



COGCC Regulations



COGCC Regulations

As reported in the last MEIA report (O’Keeffe and Berry, 2019; 2021), 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 and Berry, 2021). During 2019 and 2020, the COGCC worked on rule and policy changes associated with implementing SB19-181. This included several rule making hearings in 2020, 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 will become effective in January 2021 (CDNR, 2020). 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>) (COGCC, 2020d).

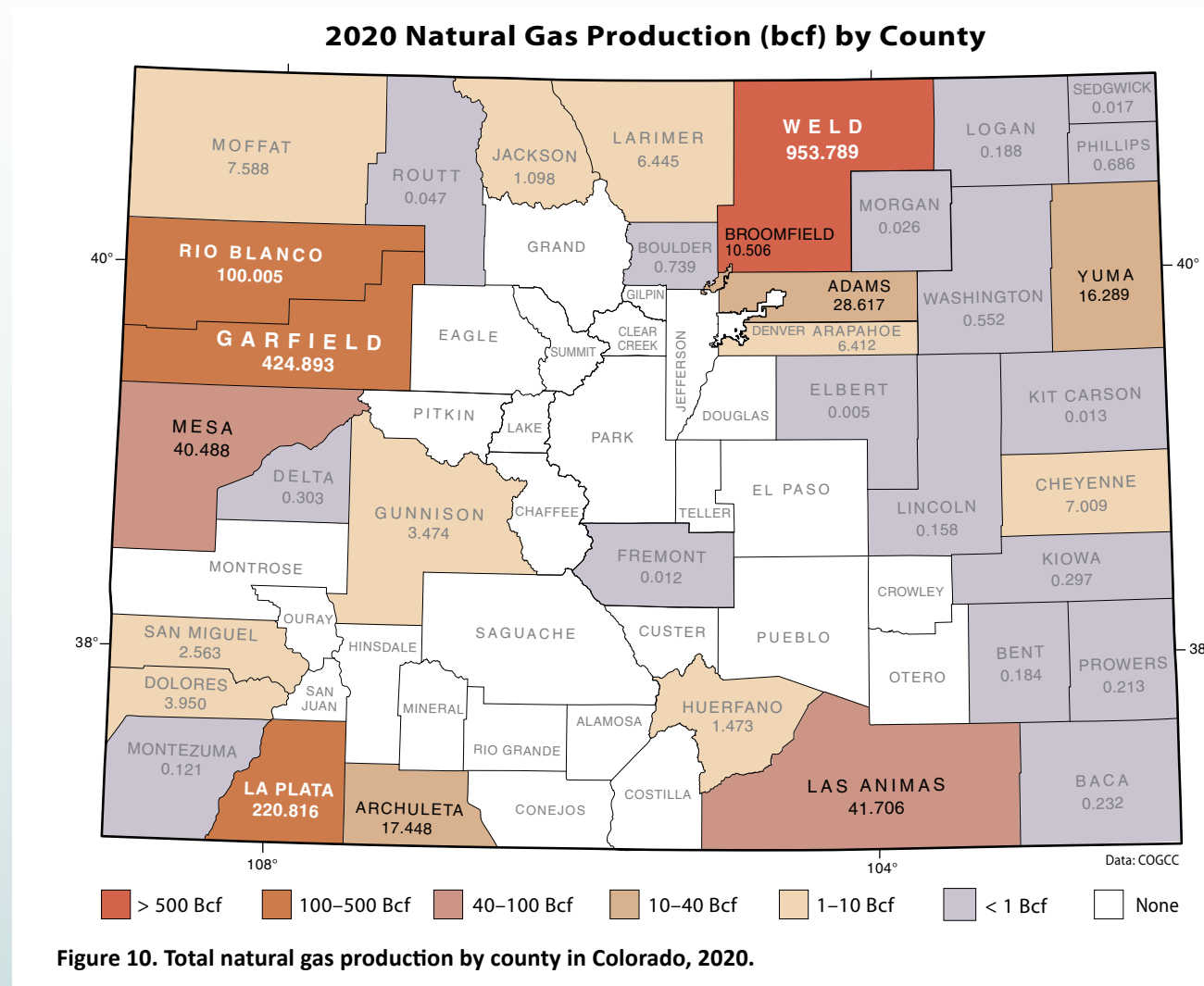


SB 19-181 also required the COGCC to conduct rulemakings to update financial assurance rules as follows (COGCC, 2021e):

“The commission shall require every operator to provide assurance that it is financially capable of fulfilling every obligation imposed by this article 60 as specified in rules adopted on or after April 16, 2019. The rule-making must consider: Increasing financial assurance for inactive wells and for wells transferred to a new owner; requiring a financial assurance account, which

must remain tied to the well in the event of a transfer of ownership, to be fully funded in the initial years of operation for each new well to cover future costs to plug, reclaim, and remediate the well; and creating a pooled fund to address orphaned wells for which no owner, operator, or responsible party is capable of covering the costs of plugging, reclamation, and remediation.”

The COGCC is conducting rulemakings on financial assurance in 2021 (COGCC, 2021e).



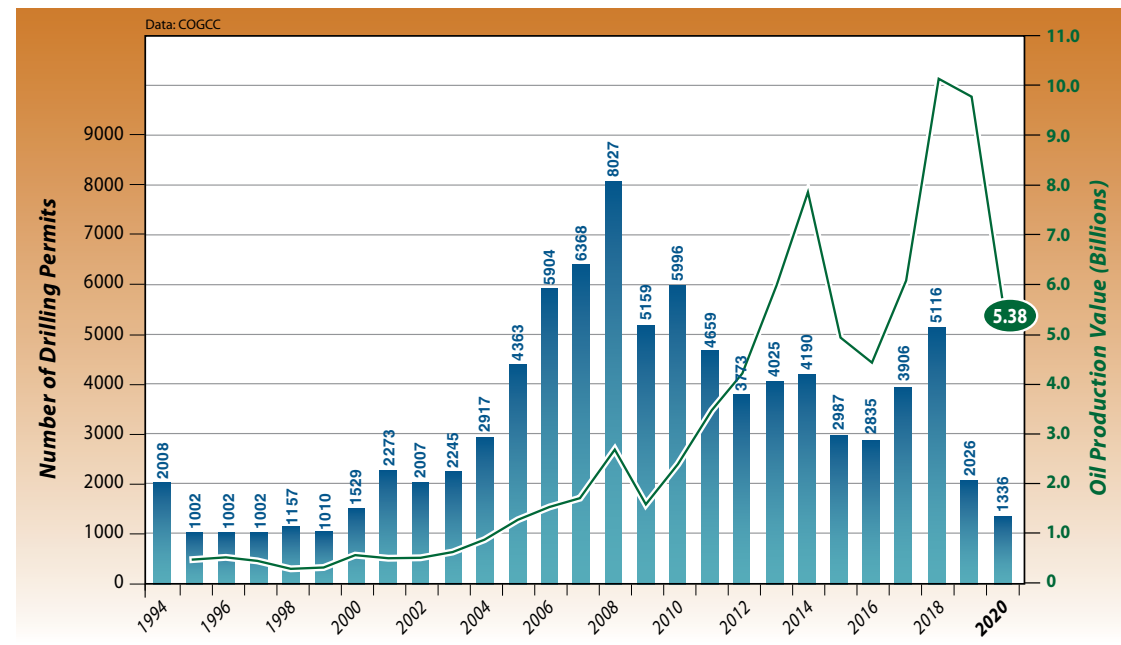


Figure 11. Annual oil and gas drilling permits and oil production value in Colorado, 1994-2020.





CONVENTIONAL ENERGY RESOURCES: COAL

Coal production in the U.S. decreased 24.2% in 2020 compared to 2019 (EIA, 2021b). However, coal is still a significant source of the state's electrical power. Per the EIA, 36% of the electricity generated in Colorado in 2020 came from coal-fired power plants (EIA, 2021g). This is a decrease of ~20% from last year. In 2020, 30% of electric generation in Colorado was from renewable sources, especially wind and solar power (EIA, 2021g). For comparison, in 2015, 60% of the electricity generated in Colorado came from coal. The 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, and the declining costs and growing use of renewable energy sources.

Between 2011 and mid-2020, 96 gigawatts (GW) of coal electricity generating capacity were retired, or switched to another fuel, and another 25 GW is expected to shut down by 2025 (EIA, 2020a). 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). For comparison, at the end of 2020, the U.S. had ~1,117 GW of total utility-scale electricity generating capacity and ~27.7 GW of small-scale solar photovoltaic electricity generating capacity (EIA, 2021h). In 2019, carbon dioxide emissions associated with coal-fired power plants reportedly decreased by 14.6% which is the largest annual fuel emission decrease in the EIA's annual carbon dioxide data series dating back to 1973 (EIA, 2020b). As of 2019, U.S. carbon dioxide emissions from motor gasoline exceeded coal (EIA, 2020b). In 2020, energy-related carbon dioxide emissions decreased by 11% primarily due to the impacts of COVID-19. Carbon dioxide emissions from coal associated with the U.S. power sector decreased the most (19%) in 2020 (EIA, 2021i).

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 2040) (Denver Post, 2017; S&P Platts, 2021).

- 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 (Colorado Sun, 2021).
- In 2021, the Martin Drake power plant retired its coal-fired unit and plans on shifting to natural gas (CPR, 2021) and the Pawnee Station will convert to natural gas by 2028 (S&P Platts, 2021).

Power generation in Colorado consumes about 60% of the coal mined in the state. The rest is shipped to ~20 other states (EIA, 2021j) or exported to other countries (~686,500 tons in 2020) (EIA, 2021k). Colorado has some of the cleanest burning coal 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 2020 is 10.63 million tons (DRMS, 2021a). The estimated value of Colorado coal production in 2020 is \$441 million (**Table 1 and Figure 12**) and the estimated average value of a ton of Colorado coal is \$41.45 (EIA, 2021b). Colorado coal production and average prices since 2004 are shown in **Figure 13**. In 2020, six Colorado coal mines were active (**Table 2**) employing 901 coal miners (DRMS, 2021a) (**Figure 14**). In 2020, Colorado was ranked 13th in coal production in the U.S. (**Figure 15**) as it was in 2019 (EIA, 2021b). Wyoming, the leading U.S. producer by far, 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, 2020b). 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

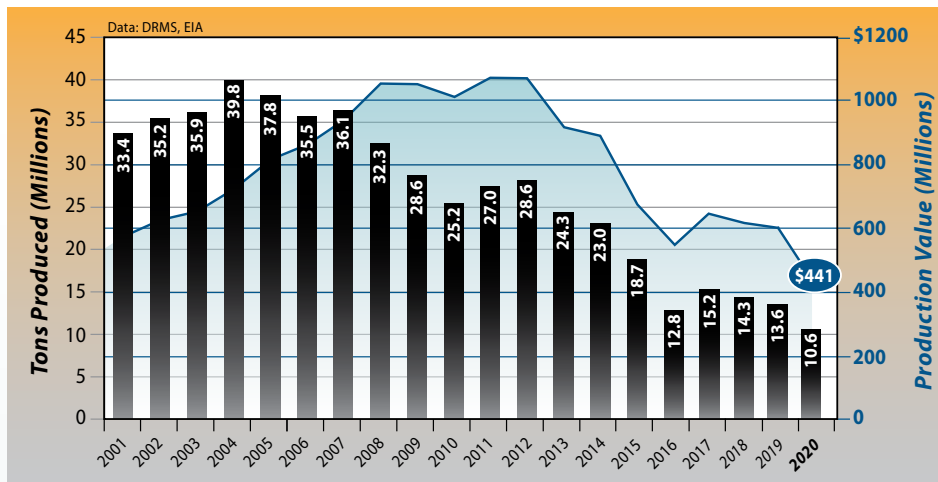


Figure 12. Production and value of coal mined in Colorado, 2001–2020.

Table 1. Coal production, price, value, and employment, 2002–2020.

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

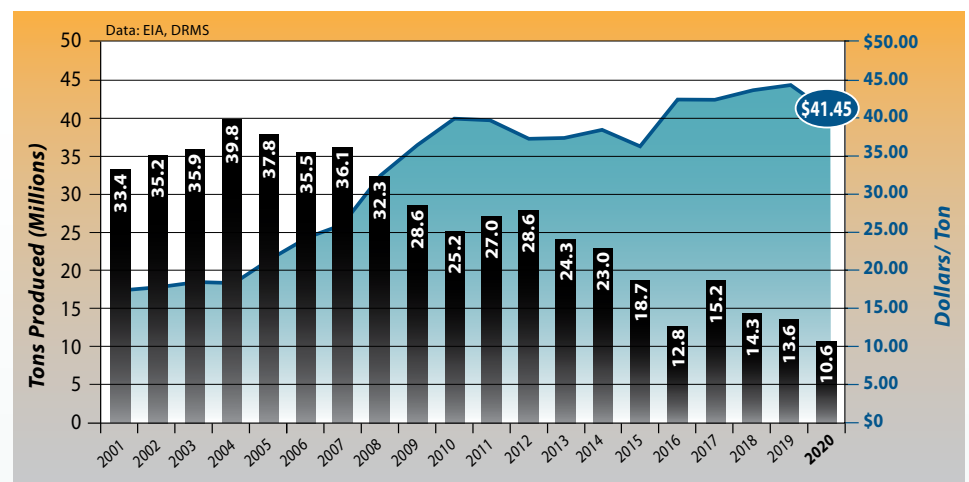


Figure 13. Coal production and average annual coal price in Colorado, 2001–2020.

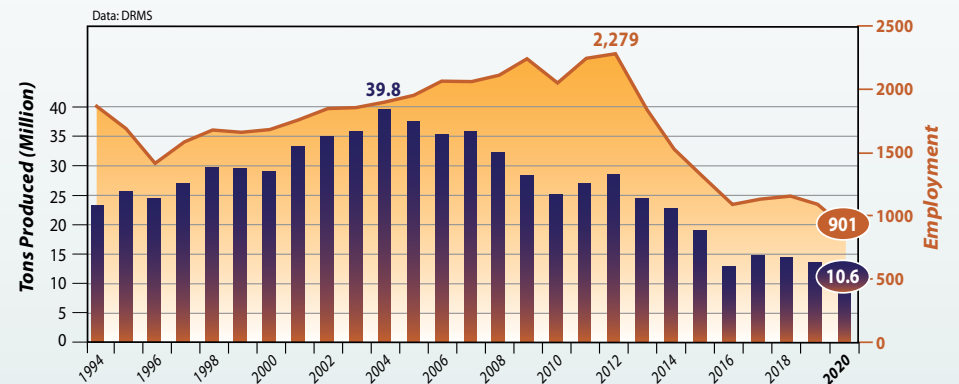


Figure 14. Coal production and employment in Colorado, 1994–2020.

Table 2. Active coal mines in Colorado, 2020.

Mine	Operator	County	Mine Type	2020 Prod. (tons)
Bowie #2	Bowie Resources Ltd.	Delta	Underground	shut down
Colowyo	Colowyo Coal Co. L.P.	Moffat	Surface	1,597,967
Deserado	Blue Mountain Energy	Rio Blanco	Underground	2,716,129
Foidel Creek	Twentymile Coal Co./Peabody Energy	Routt	Underground	2,543,911
King II	GCC Energy LLC	La Plata	Underground	657,782
Trapper Strip	Trapper Mining Inc.	Moffat	Surface	1,954,282
West Elk	Mountain Coal Co./Arch Coal	Gunnison	Underground	4,157,835
Total				13,627,924

Data: DRMS

and the Colorado School of Mines are working with both parties, coal mines, and power plant operators to perform an assessment of REEs and critical minerals in coal and coal waste streams within these regions.

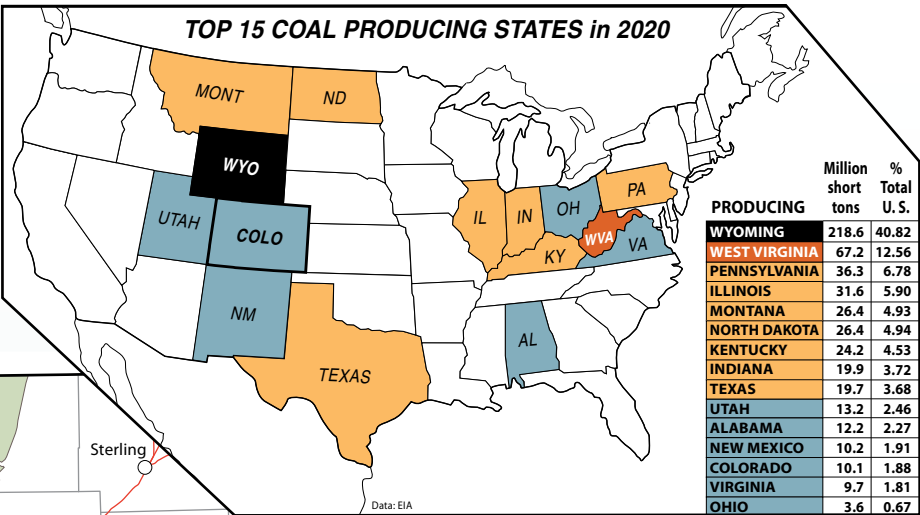


Figure 15. Top 15 coal-producing states in 2020.

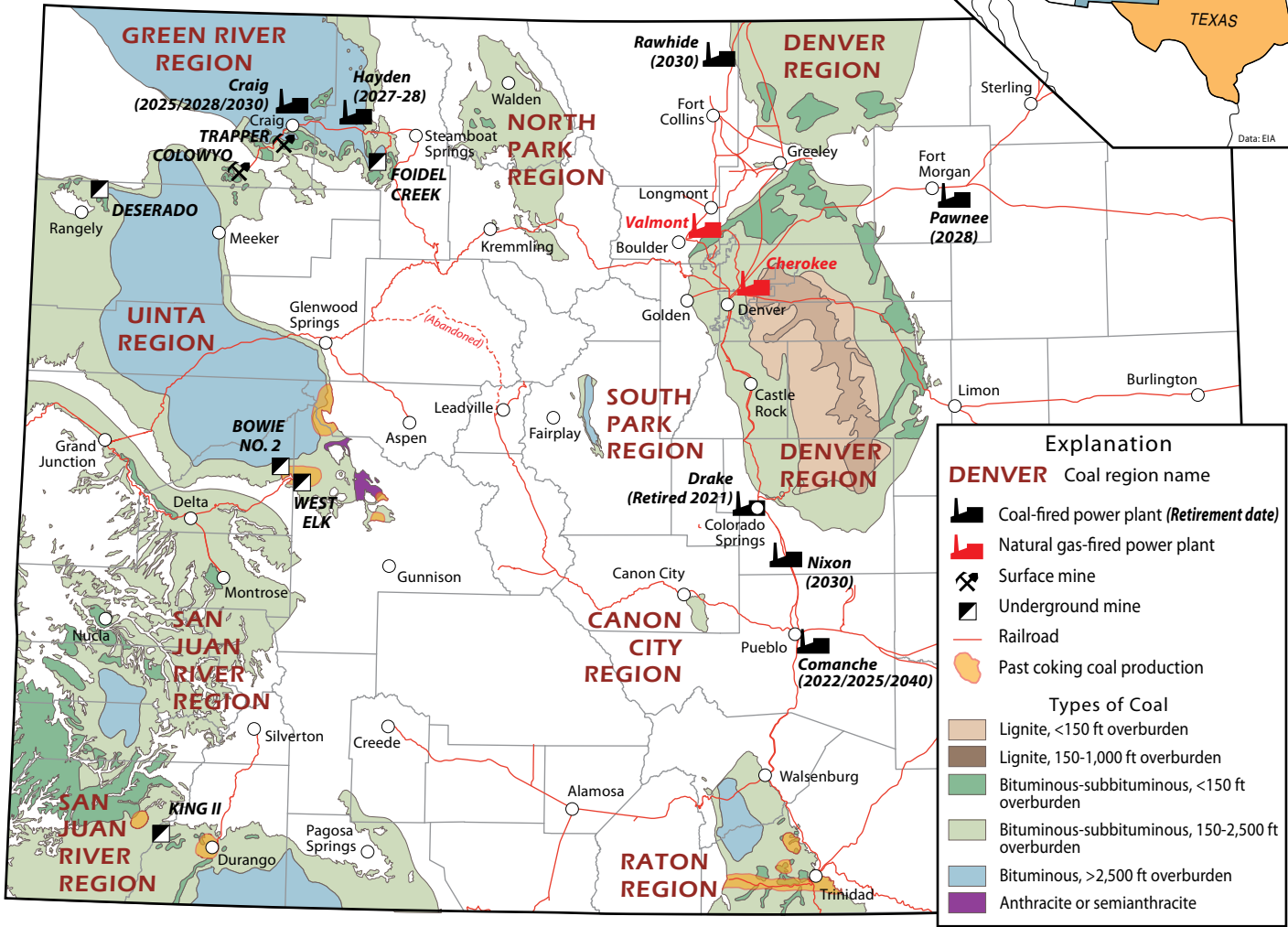


Figure 16. Locations of active coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2020. Estimated retirement dates for coal-burning units are in parenthesis.

CONVENTIONAL ENERGY RESOURCES: URANIUM

Nuclear energy accounted for 19.7% of U.S. electricity production in 2020 (EIA, 2021l). At the end of 2020, there were 56 nuclear power plants with 94 nuclear reactors operating in 28 states (EIA, 2021m). Colorado is one of about twenty states that did not generate electricity from nuclear energy. Two new nuclear reactors are under construction in Georgia and are expected to come online between 2022 and 2023 (EIA, 2021m; Associated Press, 2021). 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, 2021n).

Figure 17 shows the average annual uranium prices in the U.S. over time. 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 from \$25.64 to \$29.96 per pound in 2019 and 2020, respectively. **Figure 18** shows the estimated annual production of uranium concentrate in the U.S. between 1996 and 2020. Uranium spot prices spiked in late 2021 and reached ~\$50 per pound due to purchases by a Canada-based investment fund (S&P, 2021a). However, it is unknown if this activity will change future long-term prices which averaged ~\$43 in October 2021 up from \$34.50 per pound in January 2021 (Cameco, 2021).

Although Colorado has been a producer of uranium in the past, there are currently no concentrate producing uranium mines or mills in Colorado. The proposed Pinon Ridge uranium mill located in Montrose County is on hiatus due to a 2018 court ruling (CDPHE, 2020). Uranium concentrate production from U.S. mines in 2019 was the lowest recorded since 1949 (EIA, 2020b). In 2019, the U.S. produced uranium concentrate from five in-situ leaching facilities, four in Wyoming and one in Nebraska, and one underground mine (EIA, 2020b). Domestic uranium production for 2020 was unavailable (the EIA withdrew data to avoid disclosure of individual company data). Per the EIA website (EIA, 2021o), at the end of 2020, two Wyoming operations were operating with a joint capacity of 7.5 million pounds of U_3O_8 per year, nine in-situ recovery plants were on standby, and eight in-situ recovery plants were planned in New Mexico, South Dakota, Texas, and Wyoming. The “Other Exploration Activities and Mining Information” section of this report includes more information on uranium and vanadium in Colorado.

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

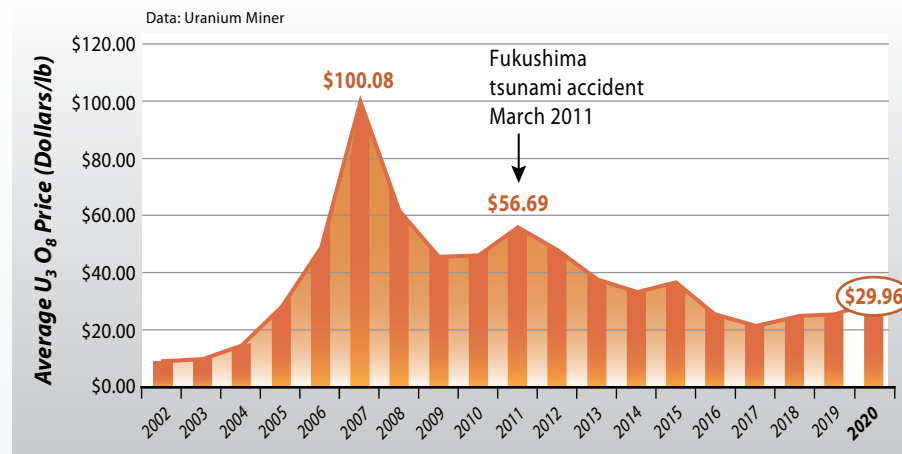


Figure 17. Average annual U_3O_8 price per pound in U. S., 2002–2020.

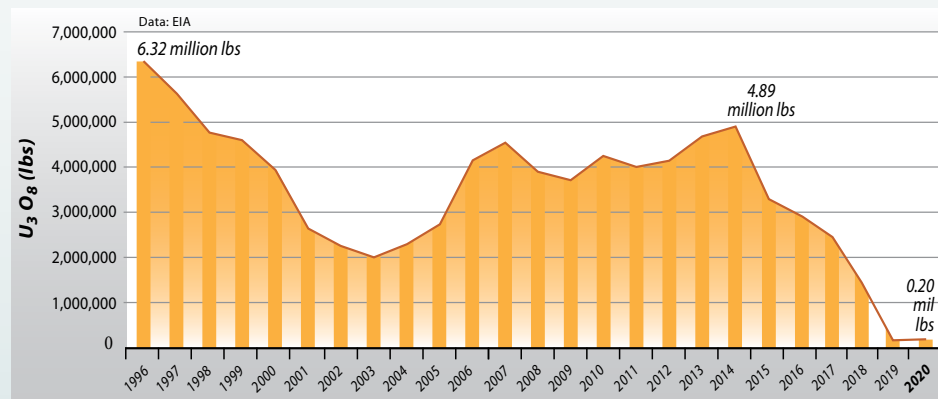


Figure 18. Annual production of uranium concentrate in U. S., 1996–2020.

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 2020, most of the uranium purchased and delivered to U.S. civilian nuclear power reactors came from other countries including Canada (22.4%) and Kazakhstan (22.1%) (EIA, 2021n). About 47% of the total uranium purchased by U.S. civilian nuclear power reactors originated in Kazakhstan, Russia, and Uzbekistan (EIA, 2021n). In April 2020, the DOE released a report by the president's Nuclear Fuel Working Group that recommended steps to assure a continued supply of uranium for U.S. nuclear power reactors and strategic defense needs. The report includes the following statements (DOE, 2020c; DOE, 2020d):

- *“First, the U.S. Government will take bold action to revive and strengthen the uranium mining industry, support uranium conversion services, end reliance on foreign uranium enrichment capabilities, and sustain the current fleet, removing strategic vulnerabilities across the nuclear fuel cycle and restoring a world-class workforce to provide benefits to the U.S. and to compete in the international market.”*
- *“Second, the U.S. Government will leverage American technological innovation and advanced nuclear Research, Development, and Demonstration (RD&D) investments to accelerate technical advances and regain American nuclear energy leadership.”*

- *“Finally, the U.S. Government will move into markets currently dominated by Russian and Chinese State-Owned Enterprises (SOE) and recover our position as the world leader in exporting best-in-class nuclear energy technology, and with it, strong non-proliferation standards.”*

In December 2020, Congress passed the Consolidated Appropriations Act of 2021 which includes \$150 million to start a uranium reserve program (WNN, 2020). The full text of the act is available here: <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>. The DOE released a request for information regarding establishment of the DOE uranium reserve program in August 2021 (Federal Register, 2021b).

NON-FUEL MINERAL RESOURCES

Non-fuel mineral resources include metals, industrial minerals, and construction materials (e.g., cement, crushed rock, sand, and gravel). The total U.S. 2020 non-fuel mineral production value was \$82.3 billion, a ~4.6% decrease from last year's total of \$86.3 billion (USGS, 2021a). Colorado ranked 17th in U.S. non-fuel mineral production value and produced an estimated \$1.62 billion, or ~1.96% of the estimated total U.S. production value (USGS, 2021a). **Figure 19** shows the estimated non-fuel mineral production value in Colorado over time.

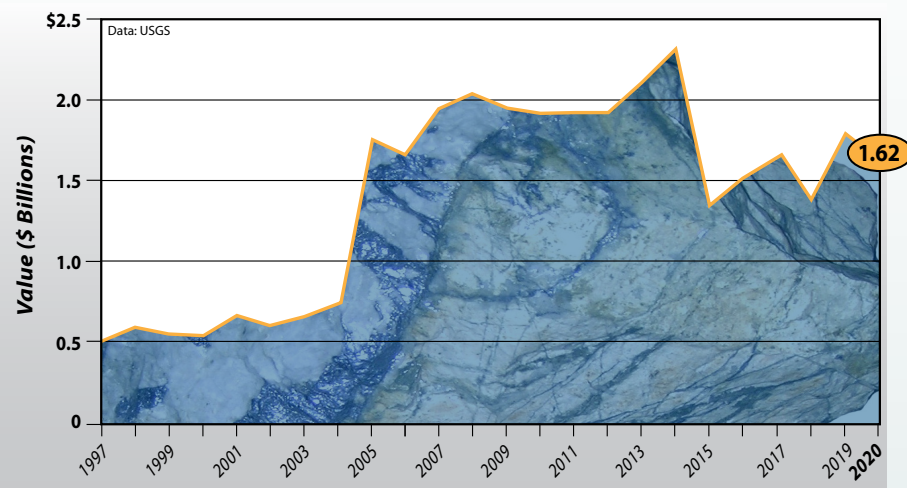


Figure 19. Total non-fuel mineral production value in Colorado, 1997–2020.

Metal Mining

Metals mined in Colorado include gold and molybdenum. The CGS estimates that the 2020 production value of gold and molybdenum in Colorado is ~\$690 million. This is ~11.6% lower than the value of these two commodities in 2019 of ~\$781 million due to lower production. Silver production in Colorado is a by-product of gold mining. Silver production values for Colorado were unavailable.

Molybdenum

In 2020, metallurgical applications used 88% of the total molybdenum consumed in the U.S. (USGS, 2021a). Molybdenum is typically used in the production of engineering steels (e.g., superalloys, nickel alloys, and tool steels), stainless steel, molybdenum metal and other alloys. As of last year, the U.S. is the third

largest producer of molybdenum in the world and produced an estimated 108 million pounds in 2020, valued at an estimated \$840 million, based on average prices reported by the USGS (USGS, 2021a). This is ~11% higher than the 2019 estimated production of 97 million pounds. China is the top producer (~265 million pounds in 2020) and Chile is the second largest producer (estimated 128 million pounds in 2020) (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 \$11.37 in 2019 to \$8.69 per pound in 2020 (Freeport, 2021a). Most of the 2020 primary molybdenum production in the U.S. was from two Colorado mines that produced ~24 million pounds combined (Freeport, 2021a). In the U.S., Colorado ranked third in molybdenum production following molybdenum recovered as a by-product of copper mining at Utah and Arizona 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 and 14 million pounds in 2020. Due to declining molybdenum prices, Freeport reduced production at Climax in April 2020 (Freeport, 2021a). However, Climax returned to normal production in

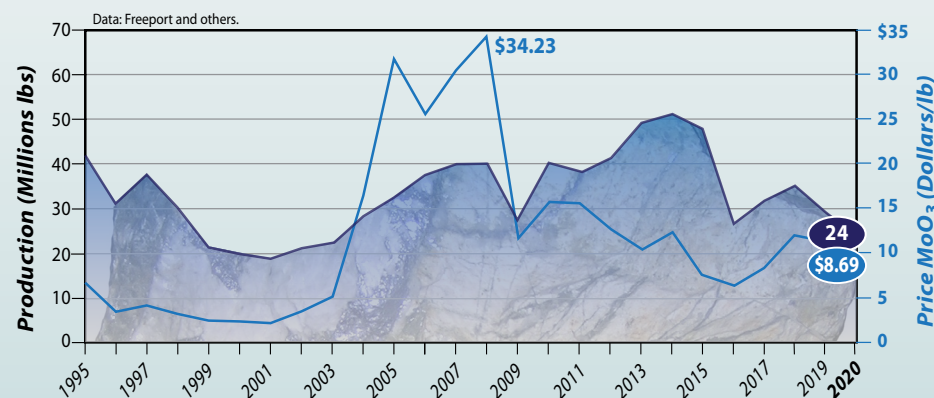


Figure 20. Molybdenum production in Colorado and average annual price 1995-2020.

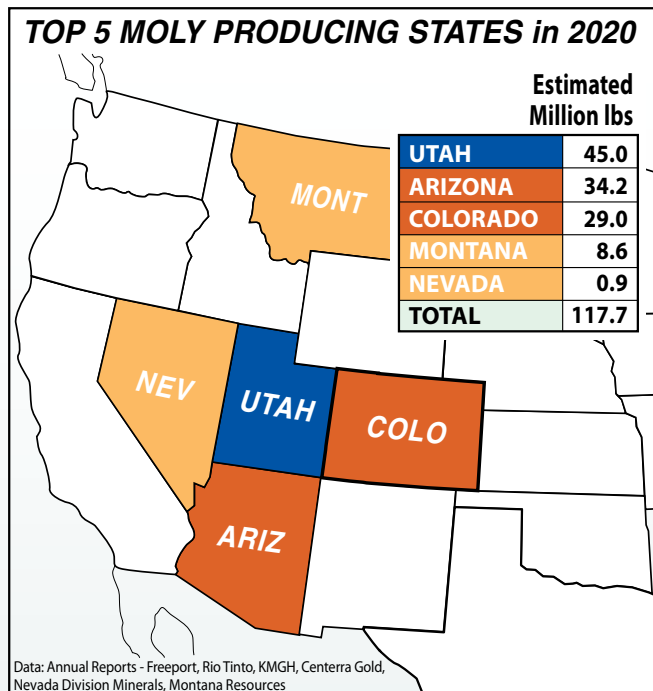


Figure 21. Top five molybdenum producing states, 2020.

2021 (Freeport, 2021b). In 2020, Freeport also reported that the Climax Mine had 143 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, 2021a).

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, and 10 million pounds in 2020. In 2020, Freeport also reported that the Henderson Mine had 40 million metric tons of proven reserves at an average grade of 0.19% molybdenum and probable reserves of 20 million metric tons at an average grade of 0.13% (Freeport, 2021a).

Gold and Silver

U.S. gold production decreased from 200 tons (6.43 million troy ounces) in 2019 to an estimated 190 tons (6.11 million troy ounces) in 2020 with an estimated value of \$10.8 billion (USGS, 2021a). In 2020, the U.S. was the fourth largest producer

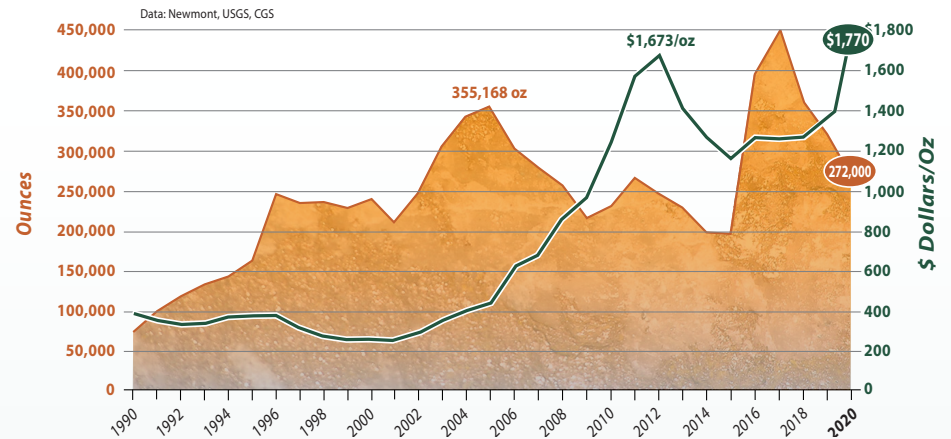


Figure 22. Colorado estimated gold production and average annual price per ounce, 1990–2020.

of gold in the world following China (380 tons), Australia (320 tons), and Russia (300 tons) (USGS, 2021a). **Figure 22** shows the price of gold and Colorado gold production from 1990 to 2020. In 2020, Colorado was the third largest producer of gold (272,000 ounces) in the U.S. (**Figure 23**) following Nevada (~2,642,706 ounces) and Alaska (~663,284 ounces). The average gold price increased in 2020 to \$1,770 per ounce from \$1,395 per ounce in 2019 (USGS, 2021a).

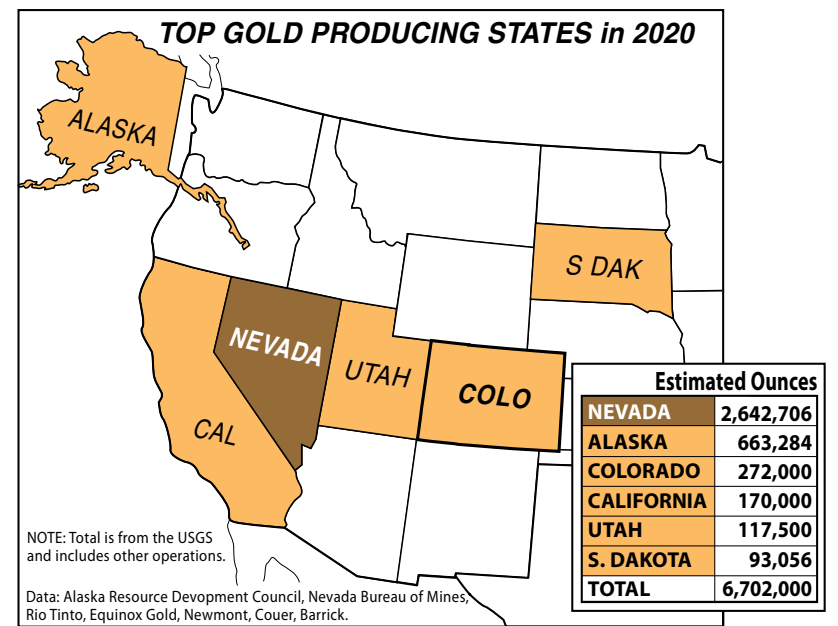


Figure 23. Major gold-producing states in 2020.

Gold production at Newmont Corporation's (Newmont) Cripple Creek and Victor (CC&V) open pit mine located in Teller County decreased from 322,000 ounces in 2019 to 272,000 ounces in 2020 due to leach recovery timing and lower ore grades milled at CC&V (Newmont, 2021). CC&V also produces silver; however, the mine does not report production numbers for silver. In 2019, Newmont acquired Goldcorp Inc. and entered into 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 2020, it was the largest producer of gold in the world (5.8 million ounces) (NS Energy, 2021).

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 2020, two of the larger gold placer mines in Colorado include the Box Creek Placer Mine in Lake County and the Hector Placer located in Park County (DRMS, 2021b). As of December 2021, 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, 2021a).

Other Exploration Activities and Mining Information

Worldwide exploration budget estimates for nonferrous metals declined ~11% from ~9.8 billion in 2019 to ~8.7 billion in 2020 (S&P, 2021b). The 2020 budget estimate is still above the low reported in 2016. This includes planned spending for gold, silver, base metals, platinum group metals, diamonds, uranium, rare earth elements, and potash (S&P, 2021b). Most of this estimated total budget is for exploration targeting gold (52%), copper (21%), and lead/zinc (5%) (S&P, 2021b).

Exploration and development projects that have undergone at least some 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, May Day Mine, Ouray Silver Mine (Revenue-Virginus), San Juan Silver Project, and Klondike Mine.

Viscount Mining Corp. (Viscount) completed exploration drilling during 2020/2021 at their property located within the historic Hardscrabble mining district near Silver Cliff, Colorado. Silver mineralization occurs in a rhyolite tuff (Viscount, 2021a) deposited ~35.4 to 32 million years ago (McIntosh and Chapin, 2004) from the Silver Cliff caldera. The company completed a joint geophysical/geochemical survey in 2021. Viscount plans on performing more exploration in 2021 which will focus on previous drilling discoveries and expanding their Kate

silver resource. The company will use the information to update their current resource estimates (Viscount, 2021b). As indicated on their website, Viscount reported NI 43-101 resources (effective 15 April 2018) of 2.1 million tons of indicated resources with grades of 84 grams per ton silver (5.6 million ounces of silver) and inferred resources of 3.2 million tons with grades of 70 grams per ton silver (7.1 million ounces of silver) (Viscount, 2021a). Viscount also completed exploration drilling in 2021 at their Passiflora resource (Viscount, 2021c).

As of June 2020, Dateline Resources (Dateline) spent the last two years consolidating ownership of several historic gold mines in the Gold Brick mining district including 39 patented and 20 unpatented claims associated with the Gold Links Mine, and patented claims associated with the Lucky Strike Mill and Mineral Hill historic mine. They also developed a decline (~1,000 feet), conducted over 10,000 feet of diamond drilling, recommissioned the Lucky Strike Mill, and sold their first concentrate produced from commissioning ore (Dateline, 2020a). Later in 2020, Dateline completed a surface mapping program and surface sampling of mine dumps, float, and exposed shafts (Dateline, 2020b). In 2021, Dateline planned on underground and surface drilling, underground development, and processing of ore at the company's Lucky Strike Mill (Dateline, 2021a). At the end of June 2021, Dateline planned on completing the drilling and development program by the end of 2021 (Dateline, 2021b). As reported in 2020 (O'Keeffe and Berry, 2019), the Gold Brick mining district 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.

In 2016, Libero Copper (Libero) entered into an option agreement to purchase the Tomichi porphyry Cu-Mo deposit located in Gunnison County. The parties amended the agreement in July 2020 including an option for Libero through their subsidiary Libero Mining Limited to acquire 100% of Tomichi until December 2022 (Libero, 2020). In January 2021, Libero closed a transaction with Zacapa Resources Ltd. (Zacapa) to sell Libero Mining Limited to them in return for Zacapa shares. Libero now owns 4.1% of Zacapa (Libero, 2021). Per Libero (2021), *"Mineralization at Tomichi is a typical porphyry deposit characterized by disseminated and fracture controlled molybdenite and chalcopyrite hosted by a mid-Tertiary, potassic altered, intrusive system dominated by a porphyritic quartz monzonite. The mineralized porphyry is exposed at surface on top of Copper Hill. Diamond drilling has intersected copper-molybdenum mineralization over a surface area in excess of 1,500 meters by 800 meters, to a depth of at least 600 meters and remains open to the north, east and at depth.....The resource estimate for Tomichi consists of an inferred mineral resource of 711 million tonnes at a grade of 0.33% copper equivalent containing 3.3 billion pounds of copper, 555 million pounds of*

molybdenum, 393 thousand ounces of gold, 46 million ounces of silver and 339 thousand pounds of rhenium." Zacapa is considering completing a preliminary economic assessment followed by a drill program in 2022 (Zacapa, 2021).

In 2021, Metallic Minerals Corp. (Metallic Minerals) announced the start of their first phase of drilling at their La Plata silver-gold-copper project in La Plata County. The company designed the drill program to explore mineralization in the porphyry system and to assist with developing their new resource estimate. The mineralization is associated with a porphyry copper system with associated epithermal silver and gold replacement deposits. Per Metallic Minerals, previous exploration defined a northeast trending zone of copper-silver-gold mineralization covering an area of at least 3 kilometers (km) by 1 km with over 1 km of vertical relief with potential for additional resources. Also, the silver and gold-rich epithermal system reportedly measures at least 8 km by 2 km and hosts 56 identified vein, replacement, and breccia structures (Metallic Minerals, 2021). The La Plata Property is in the La Plata mining district northwest of Durango. Reportedly, the property covers over 12 square miles and includes the Allard and Copper Hill areas. According to Metallic Minerals, previous exploration on the property confirmed the presence of an alkali copper porphyry system with associated epithermal silver and gold deposits. 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, 1949; Metallic Minerals, 2020).

Zephyr Gold USA Ltd. (Zephyr), a wholly owned subsidiary of Zephyr Minerals Ltd., holds mineral claims at their Dawson – Green Mountain Property located southwest of Cañon City in Fremont County. The Dawson Project, located on the eastern end of the property, includes gold mineralized areas within a Proterozoic-age granite and associated rocks. In 2018, Zephyr completed additional geological mapping, drilling, sampling, and a geophysical survey at the Dawson Property and expanded its holdings to include a copper-gold prospect to the west named the Green Mountain Property. In 2019, they also leased a property in the center and adjacent to the Dawson-Green Mountain sections of the property called El Plomo. This area is reportedly a silver-lead-zinc prospect. Zephyr recently completed an airborne magnetic and electromagnetic survey at this property (O’Keeffe and Berry, 2021). In 2020, Zephyr completed a drilling program and focused on more exploration and development at their Dawson and Green Mountain properties (Zephyr, 2020; O’Keeffe and Berry, 2021). In 2021, Zephyr submitted an application for a DRMS mining permit for the Dawson gold deposit (Zephyr, 2021a). As reported by Zephyr (Zephyr, 2021b), *"Success in obtaining a mining permit at Dawson will, subject to funding,*

enable the implementation of an underground development program which will include construction of drill stations to undertake infill drilling on the current resource as well as exploratory drilling at depth." Zephyr plans on completing an updated resource estimate after they complete the underground drilling program (Zephyr, 2021b).

Uranium and Vanadium

There were several recent activities associated with uranium and vanadium properties in Colorado mainly within the Uravan mineral belt (Uravan) which generally extends from western Montrose and San Miguel counties through southwestern Mesa County (Nelson-Moore and others, 1978). The Uravan contains uranium and vanadium deposits predominantly in the Salt Wash Member and Brushy Basin Member (conglomerate-rich portions) of the Jurassic Morrison Formation that have relatively closer spacing, larger size, and are higher grade than adjacent deposits (Nelson-Moore and others, 1978; Chenoweth, 1980). As reported by Chenoweth (1980), *"the belt includes the Gateway, Uravan, Paradox, Bull Canyon, Gypsum Valley, and Slick Rock mining areas. Given recent exploration, it appears that the belt concept, developed over 25 years ago, is oversimplified and that large ore bodies in the Salt Wash are not restricted to the belt."* Between 1948 and 1978, the Colorado portion of the Uravan area produced over 63.3 million pounds of U₃O₈ (over 12.7 million tons averaging 0.25% U₃O₈) and over 331.7 million pounds of vanadium were recovered as a co-product (Chenoweth, 1978). Several other major uranium and/or vanadium deposits are located in Colorado outside of the Uravan and are summarized by the CGS (CGS, 2021). A few of the recent activities associated with uranium and vanadium exploration in Colorado are summarized below.

In June 2020, Delecta Ltd. (Delecta) announced an investment in Sunrise Minerals Inc. (Sunrise) that holds the REX uranium-vanadium project that includes 256 contiguous claims located in Montrose County. The claims are in areas with historic uranium and vanadium production in the Uravan mineral belt. Analysis of 12 samples from their property in 2021 detected an average grade of 0.22% U₃O₈ with a high of 0.53% (Delecta, 2021a). Delecta reported later in 2021 that they plan on mapping and sampling historic uranium mineralization. They expected to complete the assessment program by the end of 2021 and then start drill permitting (Delecta, 2021b).

In 2018, Azarga Uranium Corporation (Azarga) acquired URZ Energy which included the JB uranium exploration project in Colorado (Azarga 2019; 2020). Per Azarga, the JB project is located at the intersection of the Uravan and Lisbon Valley mining district and includes several historic uranium occurrences in the Morrison Formation. Azarga indicates that future exploration programs would target the shallow Salt Wash Member uranium deposits and the deeper Chinle and Cutler Formations (Azarga, 2020).

In 2020 and early 2021, Western Uranium and Vanadium Corporation (Western Uranium) continued to mine and stockpile ore at the Sunday Mine Complex located in the Uravan. In January 2021, Western Uranium reported (Western Uranium, 2021), *"Western's Sunday Mine Complex project during 2019/2020 established the mines are in ready-to-produce status. These permitted and developed conventional mines can be restarted with minimal capital expenditure. The first uranium/vanadium ore production was stockpiled underground and remains ready for delivery when COVID-19 and market conditions permit."*

Critical Minerals

As reported last year, the 2017 Presidential 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, is 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 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, fluor spar, 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, 2021a; 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, 2021a). The USGS is seeking comments on the critical minerals and methodology associated with the new list (Federal Register, 2021a; Nassar and Fortier, 2021).

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 order) zinc, tungsten, fluor spar, 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.

The CGS is currently working with the USGS to determine areas that may contain potential resources of critical minerals in Colorado. For more on critical minerals in Colorado, see the CGS website: <https://coloradogeologicalsurvey.org/minerals/strategic-critical/>. Between 2019 and 2021, the USGS hosted three 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. USGS funds geological mapping projects associated with these priority areas through the USGS Earth Mapping Resources Initiative (EarthMRI) with matching funds from state surveys.

In 2021, the White House issued an executive order on securing U.S. supply chains (U.S. White House, 2021a). The order includes a 100-day supply chain review that includes reports on risks in the semiconductor manufacturing and advanced packaging supply chains; risks in the supply chain for high-capacity batteries, including electric vehicle batteries; risks in the supply chain for critical minerals and other identified strategic materials including rare earth elements; updates to the executive order No. 13953 addressing the threat to the domestic supply chain from reliance on critical minerals; reports on the supply chains for the defense and energy industrial base, as well as several other reports on other supply chains and policy recommendations to address risks (U.S. White House, 2021a). In June 2021, the White House issued a final report on the executive order with tasks associated with strengthening U.S. supply chains (U.S. White House, 2021b). Several tasks were presented in the final report that include: securing a domestic supply chain for advanced batteries; investing in sustainable domestic and international production and processing of critical minerals; investing in sustainable supply chains at home and abroad; combating unfair trade practices; investing in the development of next generation batteries and provide financing to support advanced battery production; creating new standards for the extraction and processing of critical minerals at home and abroad; and identifying potential sustainable production and processing locations for critical minerals. The final report (U.S. White House, 2021b) contains several other tasks. In August 2021, a bill (H.R. 5033) allowed new tax credits for the domestic production of rare earth magnets. These magnets must be comprised of an alloy of neodymium, praseodymium, iron, boron, dysprosium or an alloy of samarium, gadolinium, and cobalt (Congress, 2021).

SEC Modernization of Property Disclosures for Mining Registrants

In 2018, the U.S. Securities and Exchange Commission (SEC) announced their decision to amend current property disclosure requirements under the Securities Act of 1933 and Securities Exchange Act of 1934 (SEC, 2021). These amendments will require businesses with mining operations to disclose information with regards to mineral resources and reserves. The SEC will also include other requirements to provide investors with more specific information with regards to a business's mining operations and prospects. The new rules provide additional requirements for the qualified person who provides the disclosures. The SEC has determined that future compliance with these new amendments and rules will be required during the SEC registrant's first fiscal year beginning on or after January 1, 2021 (SEC, 2021).

Proposed Federal Mining Law Reform

Two proposed mining bills were introduced to federal legislators in 2019 including the Hardrock Mining and Reclamation Act of 2019 (S. 1386) (Congress, 2019), originally introduced in 2015, and the Hardrock Leasing and Reclamation Act of 2019 (H.R. 2579) (Congress, 2020). As of December 2021, lawmakers have yet to vote on these bills. The current Mining Law of 1872 governs the acquisition of federal public lands for minerals by the "location and maintenance" of mining claims (BLM, 2021). Locatable minerals include metallic-bearing minerals as well as some non-metallic minerals. Both bills attempt to modify current requirements associated with locatable minerals on federal public lands. In May 2019, S. 1386 was referred to the U.S. Committee on Energy and Natural Resources (Congress, 2019). As summarized by Congress (Congress, 2019), the proposed S. 1386 modifies requirements associated with hardrock mining on federal land including:

- *"Prohibits the United States from issuing a patent for any mining claim, millsite, or tunnel site unless a patent application was filed with the Department of the Interior by September 30, 1994.*
- *Subjects production of all locatable minerals from any mining claim to a reasonable royalty established by Interior.*
- *Requires an exploration permit and mining operations permit for non-casual mining operations.*

- *Establishes the Hardrock Minerals Reclamation Fund for the reclamation and restoration of land and water resources adversely affected by past hardrock minerals and mining activities.*
- *Requires consultation with Indian tribes prior to the undertaking or issuing of a permit for mineral activity that has tribal implications.*
- *Establishes civil penalties for violation of surface management or operation requirements and related regulations."*

In October 2019, the U.S. Natural Resources Committee (NRC) voted to advance H.R. 2579 as well as two bills to protect miner pensions and health benefits (NRC, 2019b). As summarized by Congress in August 2020 (Congress, 2020), H.R. 2579 includes the following:

- *"Prohibits the issuance of a patent for certain mining or millsite claims.*
- *Establishes a permitting and leasing system for hardrock mining.*
- *Establishes a 12.5% royalty on new mining operations and an 8% royalty on existing operations, with an exemption for small miners.*
- *Protects special places, such as wilderness study areas, roadless areas, and wild and scenic rivers, from hardrock mining activity.*
- *Requires consultation prior to undertaking any mineral activities that may have a substantial direct impact on the lands or interests of Indian tribes.*
- *Establishes an environmental standard for mining activities to ensure that mining activities prevent undue degradation of public lands and resources.*
- *Prescribes requirements for the exploration permit process and for operations permits, including financial assurances.*
- *Authorizes the use of amounts in the Hardrock Minerals Reclamation Fund for the reclamation and restoration of land and water resources adversely affected by past hardrock mineral activities and related activities."*

AGGREGATE and INDUSTRIAL MINERALS

Sand, Gravel, and Crushed Stone

In 2020, construction sand and gravel produced in the U.S. 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, 2021a). In 2020, crushed stone produced in the U.S. was primarily used for construction aggregate (72%) (especially for road construction and maintenance), cement manufacturing (16%), lime manufacturing (8%), agricultural uses (2%), and for other uses (USGS, 2021a). Most of the 1.46 billion tons of crushed stone produced domestically in 2020 was limestone and dolomite (USGS, 2021a). DRMS currently lists over 850 active permits for sand, gravel, aggregate, and aggregate-related quarries in Colorado (DRMS, 2021a).

Colorado quarry operators produced 57.1 million short tons of aggregate (sand, gravel, and crushed stone) in 2020 (USGS, 2021b) (**Figure 24**). Colorado was the seventh leading producer of construction sand and gravel in the U.S. and the estimated 2020 production value was \$312 million for sand and gravel and \$196 million for crushed stone (USGS, 2021b). 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.

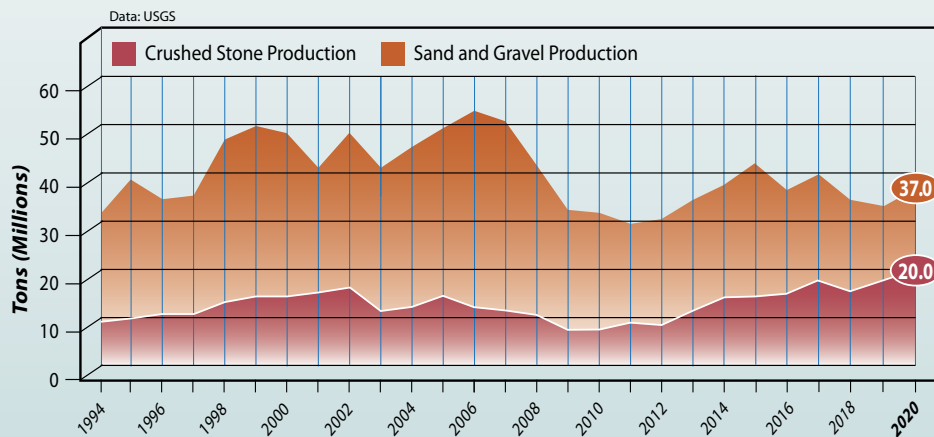


Figure 24. Aggregate production in Colorado, 1994–2020.

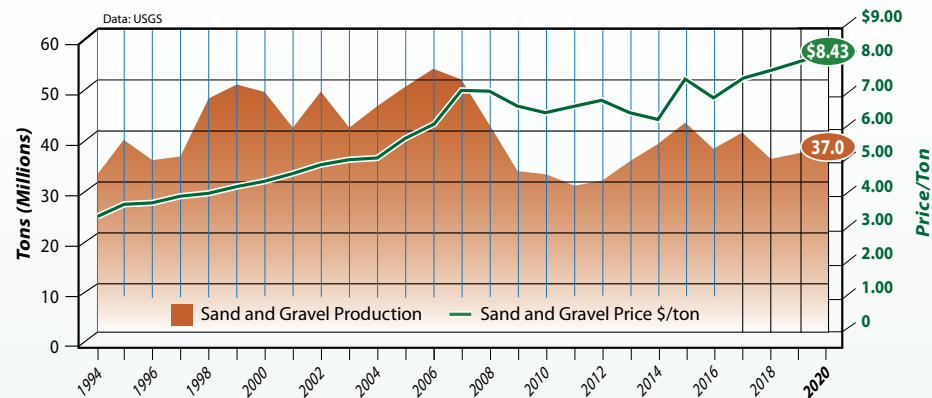


Figure 25. Price and production of sand and gravel aggregate in Colorado, 1994–2020.

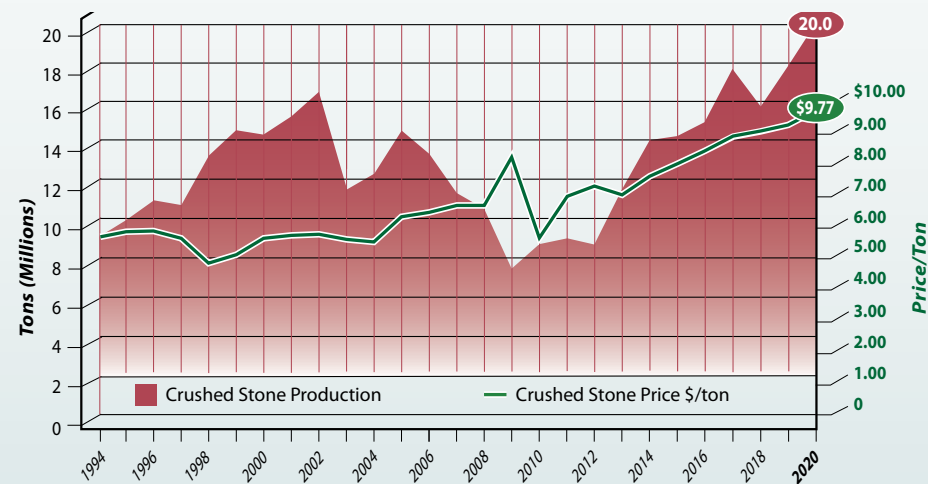


Figure 26. Price and production of crushed stone aggregate in Colorado, 1994–2020.

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). Digital versions of these aggregate resource maps can be found in another CGS publication (OF-00-09 Atlas of Sand,

Gravel, & Quarry Aggregate Resources, Colorado Front Range) that is available for download on the CGS website (Cappa and others, 2000). These maps are also available in a CGS online interactive map viewer available at the following location (copy/paste links to browser):

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

For additional information, please see the following website:

<https://cologeosurvey.maps.arcgis.com/apps/MapSeries/index.html?appid=e2f8ad18c3384707a65cc4b03f15280c>

Bipartisan Infrastructure Law

The demand for aggregates will likely increase in Colorado to assist with building infrastructure. In November 2021, the U.S. Congress (Congress) passed the Bipartisan Infrastructure Law (BIL) (Infrastructure Investment and Jobs Act) which includes provisions to rebuild U.S. roads, bridges, and rails (U.S. White House, 2021c). As summarized from the U.S. Department of Transportation (DOT) (DOT, 2021), an estimated 481 bridges and over 3,620 miles of highway are poor condition in Colorado. Based on formula funding (funding grants that are not competitive but are based on a decision rule where allocations are based on quantifiable variables such as population, etc.), Colorado could potentially receive ~\$4 billion over 5 years in Federal highway funding for highways and bridges. This is a ~28.5% increase from the current Colorado federal-aid highway formula. The BIL will also provide compete for the Bridge Investment Program (\$12.5 billion) as well as \$15 billion dedicated to “megaprojects that will deliver substantial economic benefits to communities.” Colorado would receive ~\$432 million in funding over 5 years for airport infrastructure development. Colorado is also expected to receive funds to reduce transportation-related emissions, increase transportation system resilience, highway safety traffic programs, improve public transportation, expansion of electric vehicle charging stations, as well as several other competitive funding opportunities. Additional competitive funding opportunities will include new and expanded grant programs for state and local governments (DOT, 2021).

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, 2021). 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

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

that are ground, mixed with limestone and gypsum, and used to make concrete. Three Portland cement plants operated in Colorado during 2020: 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. 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 2020 was 2.7 million tons (USGS, 2021c). Production and average cement prices are shown on **Figure 27**.

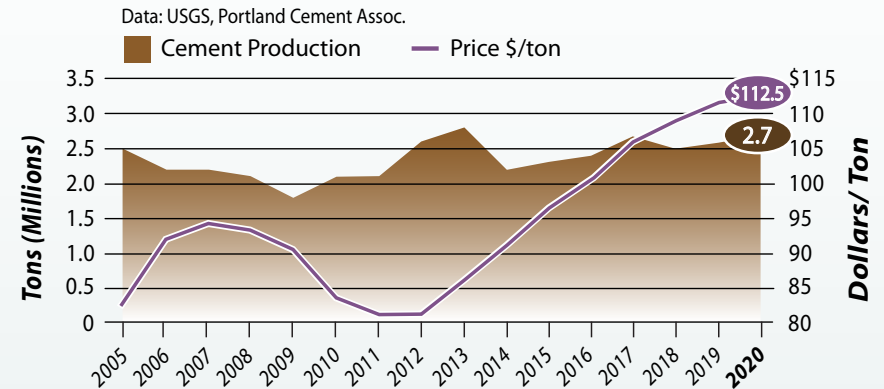


Figure 27. Price and production of cement in Colorado, 2005–2020.



Per the International Energy Agency (IEA), the cement sector is reportedly the second largest industrial source of carbon dioxide in the world and production is estimated to rise by 12 to 23% globally by 2050 due to increases in population and infrastructure construction (IEA, 2018a, 2018b). In 2020, the DOE's National Energy Technology Laboratory (NETL) awarded a \$1.5 million grant to support an engineering analysis and advancement of a commercial-scale carbon-capture project in Colorado (LaFargeHolcim, 2020). An initial scoping study was completed in June 2020 and the NETL funding will support a feasibility study to be completed by a partnership of several companies including LaFargeHolcim, Svante, Total, Oxy, and Kiewit. The study will review the carbon-capture facility design to capture up to 2 million metric tons of carbon dioxide from the LaFargeHolcim cement plant in Florence, Fremont County. The goal is to be the first to use the technology (provided by team member Svante, Inc.) at a commercial scale (LaFargeHolcim, 2020; Daily Record, 2020). Svante, Inc. (Svante) has developed a process to separate CO₂ from nitrogen in flue gas emitted by industrial plants using engineered adsorbents (Svante, 2021). A Phase 1 pre-feasibility report was completed for the project in 2021 and a Phase 2 feasibility report is due in June 2022 (NETL, 2021).

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. Arcosa Lightweight (Arcosa) produces lightweight aggregate in Jefferson County. 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, 2021).

DRMS records indicate that there are 45 active permits for clay and 4 for shale in Colorado (DRMS, 2021a). 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 brick making plant in Pueblo (Summit Brick Company, 2020). Common clay and shale production in Colorado was estimated at 297,000 short tons in 2017 and 293,000 tons in 2018 (USGS, 2021d). The estimated average price of common clay was ~\$16.00 per ton in 2020 (USGS, 2021a). Production estimates for 2019 and 2020 were unavailable.

Gypsum

Gypsum mined in Colorado is used to produce wallboard, as an ingredient in cement production, as a soil conditioner, and for other industrial uses such as

glass making and smelting. 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). There are currently 8 active mine permits associated with gypsum in Colorado (DRMS, 2021a). 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, 2021). 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. Crude gypsum 2020 production in the U.S. is 22 million tons (USGS, 2021a). Information on gypsum produced in Colorado is unavailable for proprietary reasons.

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, Inc. (Natural Soda), owned by Rincon Ltd., 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. 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, and 2020 was 188,000, 231,562, and 238,266 tons, respectively (**Figure 28**) (DRMS, 2020a).

Silica

Sand is mined in Colorado for use as a silica additive in cement manufacturing. Quartz sand from fluvial deposits has been mined for filtration and water

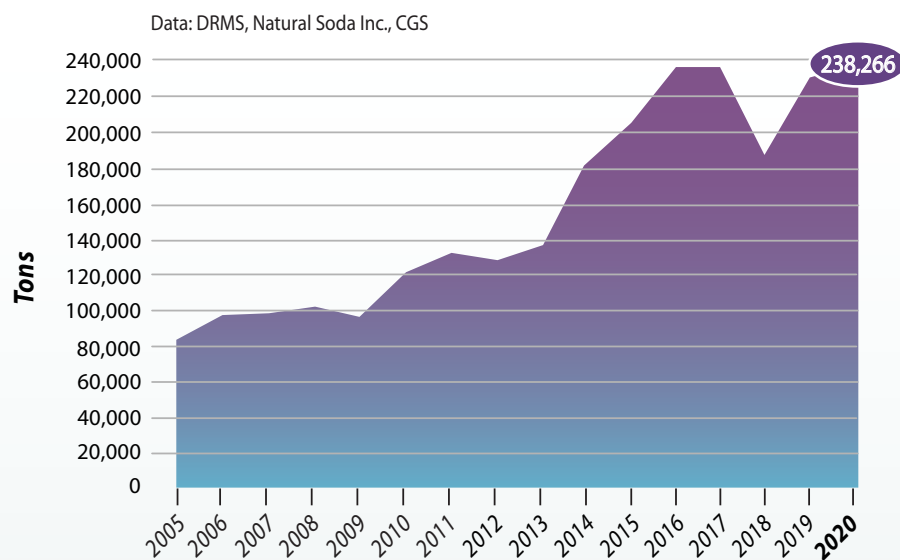


Figure 28. Estimated production of nahcolite in Colorado, 2005–2020.

well packing purposes. Depending on the application and other factors, silica prices are highly variable. The average national price for industrial silica sand and gravel reported by the USGS in 2019 and 2020 is ~\$47.30 and \$45.00 per metric ton, respectively (USGS, 2021a). As reported by the USGS, the estimated production of industrial sand and gravel decreased from 114 to 71 million tons between 2019 and 2020 (USGS, 2021a). In 2020, ~58% of the U.S. production of industrial sand was used as well-packing and cementing sand and hydraulic fracturing sand used to prop open rock fractures and facilitate the flow of oil and gas to wells (USGS, 2021a). In 2017, about 73% of industrial sand and gravel sold or used by U.S. producers was used for hydraulic fracturing, well packing and cementing. Production information of industrial sand in Colorado was not available for 2019 and 2020.

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 (USGS, 2021a). 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, 2021a). Colorado dimension stone 2020 production data were not available. In 2020, Colorado was a minor producer while Texas, Wisconsin, Indiana, Vermont, and New York accounted for ~71% of U.S. production (USGS, 2021a). The rock types sold in the U.S. in 2020 by descending value included limestone (46%), granite (25%), sandstone (11%), slate (5%), marble (4%), dolomite (4%), and other miscellaneous stones (5%) (USGS, 2021a).

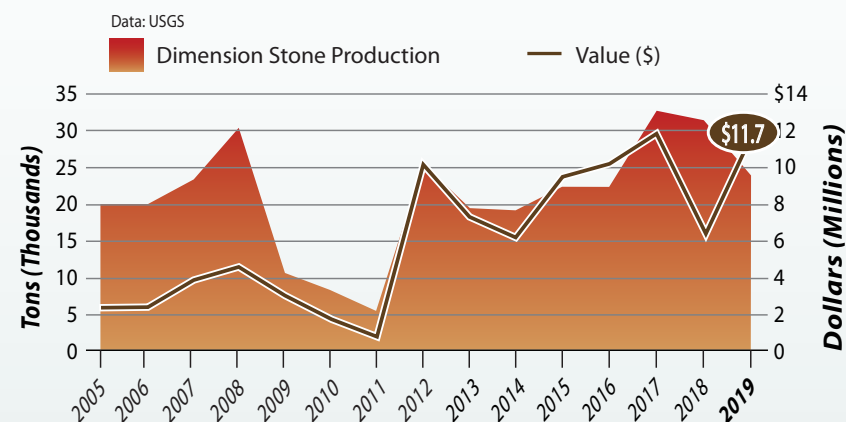


Figure 29. Production and product value of dimension stone in Colorado, 2005–2019.

INDUSTRIAL GASES (NON ENERGY)

Carbon Dioxide

Naturally occurring carbon dioxide gas (CO₂) was produced in 2020 primarily from three areas in Colorado: McElmo Dome in Montezuma County, Doe Canyon Deep in Dolores County, and the Sheep Mountain Field in Huerfano County (COGCC, 2021b). McCallum Field in Jackson County and the Rangely Field in Rio Blanco County have also produced CO₂ in the past. Kinder Morgan's McElmo Dome and the Doe Canyon Deep units are the largest producers in Colorado. About 90% of the 2020 production of CO₂ in Colorado was from Montezuma County (COGCC, 2021b). CO₂ is produced from wells in a similar way to natural gas production. Oil producers mainly use CO₂ 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). 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 2020, Colorado produced an estimated 301 billion cubic feet (Bcf) at an estimated average price of \$0.89 per thousand cubic feet (Mcf) for an estimated value of \$738 million (COGCC, 2021b). **Figure 30** shows Colorado's estimated CO₂ production for the period 1994-2020.

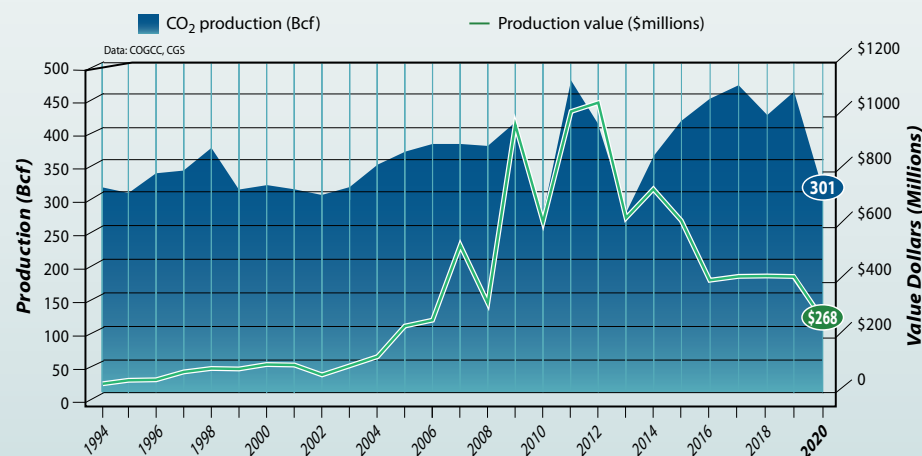


Figure 30. CO₂ production and estimated production value in Colorado, 1994–2020.

Helium

In 2020, helium was primarily used for magnetic resonance imaging, lifting gas (e.g., for lifting high-altitude equipment), analytical and laboratory applications, welding, and other applications including engineering/scientific applications, leak detection, and semiconductor manufacturing (USGS, 2021a). The price for private industry grade-A helium in 2020 was ~\$210 per Mcf (USGS, 2021a). Currently, the BLM manages the Federal Helium System under the Helium Stewardship Act of 2013. The BLM will terminate its management of the federal helium system. In April 2020, the BLM announced that it plans on disposal of the remaining federal helium inventory and assets by September 2021 after which the U.S. General Services Administration will start their statutory disposal process (USGS, 2021a).

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 40 million cubic feet (MMcf) per day which could be expanded to 50 MMcf per day (Tumbleweed, 2021). 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). Blue Star Helium Ltd. (Blue Star) announced an ~3 Bcf prospective helium resource at their Enterprise and Galileo prospects located in Las Animas County (Blue Star, 2020). The prospects are located in the Lyons Formation helium play and Blue Star is proposing to drill a well at their Enterprise prospect contingent on drilling permit approval. Blue Star or its subsidiaries also owns the mineral leases at their Galactica, Pegasus, and Argo Prospect (Blue Star, 2021).

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References

- American Gypsum, 2021, accessed December 2021, <https://www.americangypsum.com/about/locations>.
- Arcosa Lightweight (Arcosa), 2021, accessed December 2021, <https://arcosalightweight.com/about>.
- Associated Press, 2021, Georgia Power pushes back startup date of two nuclear reactors as costs mount: Associated Press, 25 October 2021, <https://www.usnews.com/news/best-states/georgia/articles/2021-10-25/new-delay-for-georgia-nuclear-reactors-as-costs-mount>.
- Azarga (Azarga Uranium Corporation), 2019, Consolidated financial statements: Azarga Uranium Corporation, 31 December 2019, <https://azargauranium.com/financial-type/annual-reports/>.
- Azarga, 2020, Consolidated financial statements: Azarga Uranium Corporation, 31 December 2020, <https://azargauranium.com/financial-type/annual-reports/>.
- BLM (U.S. Bureau of Land Management), 2021, About mining and minerals: U.S. Bureau of Land Management, accessed December 2021, <https://www.blm.gov/programs/energy-and-minerals/mining-and-minerals/about>.
- Blue Star Helium Ltd. (Blue Star), 2020, 3 Bcf prospective helium resource: Blue Star Helium Ltd., ASX announcement, 27 May 2020, <https://www.bluestarhelium.com/investor-centre/asx-announcements/>.
- Blue Star Helium Ltd. (Blue Star), 2021, 2020 annual report: Blue Star Helium Ltd., posted 31 March 2021, 57 p., <https://www.bluestarhelium.com/investor-centre/asx-announcements/>.
- 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.
- the CGS, and Ben Teschner, at the Colorado State Land Board, for their reviews. Production, price, and production values reported here are estimated and subject to change. Prices were not adjusted for inflation. This publication includes updated information as well as text from previous annual MEIA reports. Data from this report are from 2020 while other reported news is from 2021. This project was funded through state severance tax.
- Cameco, 2021, Uranium price: Cameco, accessed December 2021, <https://www.cameco.com/invest/markets/uranium-price>.
- Cappa, J.A., Sadlick J., Litke, D.W., McCormick, M.L. and Hiatt, C.S., 2000, Digital version of the 1974 Atlas 5-A: Colorado Geological Survey, Open File Report 00-09, <https://coloradogeologicalsurvey.org/publications/atlas-sand-gravel-quarry-aggregate-resources-colorado-front-range/>.
- 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/>.
- CDNR (Colorado Department of Natural Resources), 2020, Colorado Oil and Gas Conservation Commission unanimously adopts SB 19-181 new mission change rules, alternative location analysis and cumulative impacts: Colorado Department of Natural Resources, accessed December 2021, <https://dnr.colorado.gov/press-release/colorado-oil-gas-conservation-commission-unanimously-adopts-sb-19-181-new-mission>.
- CDPHE (Colorado Department of Public Health and Environment), 2020, Pinon Ridge uranium mill: Colorado Department of Public Health and Environment, accessed December 2020, <https://coloradogeologicalsurvey.org/publications/summary-coal-resources-colorado-2003/>.
- CGS (Colorado Geological Survey), 2021, Uranium: Colorado Geological Survey, accessed December 2021, <https://coloradogeologicalsurvey.org/energy/e-uranium/>.
- Chenoweth, W.L., 1978, Uranium in Western Colorado: The Mountain Geologist, v. 14, no. 3, July 1978, p. 89-96, <https://archives.datapages.com/data/rmag/mg/1978/chenoweth.htm>.
- Chenoweth, W. L., 1980, Uranium in Colorado: in Colorado Geology, Kent, H. C. and Porter, K. W., eds., Rocky Mountain Assoc. of Geologists, 1980, 221 p.
- COGCC (Colorado Oil and Gas Conservation Commission), 2021a, Colorado oil and gas information system: Colorado Oil and Gas Conservation Commission, Department of Natural Resources, accessed September 2021, https://cogcc.state.co.us/data5_ext.html#/cogis.

- COGCC, 2021b, Colorado oil and gas commission data downloads: Colorado Oil and Gas Conservation Commission, accessed August 2021, <https://cogcc.state.co.us/data2.html#/downloads>.
- COGCC, 2021c, 2020 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, 11 January 2021, 25 p., <https://cdphe.colorado.gov/sb-89-181-implementing-agencies-annual-reports>.
- COGCC, 2021d, Colorado Oil and Gas Conservation Commission implementing Colorado's oil and gas law SB19-181, mission change rulemaking series fact sheet: Colorado Oil and Gas Conservation Commission, 6 p., https://cogcc.state.co.us/documents/media/Mission_Change_200_600_800_900_1200_Series_Fact_Sheet_20201123.pdf.
- COGCC, 2021e, Financial assurance rulemaking: Colorado Oil and Gas Conservation Commission website, accessed December 2021, https://cogcc.state.co.us/hearings.html#/rulemaking_sb181_financial_assurance.
- Colorado Sun, 2021, Xcel Energy moves up closure dates for coal-fired power plant near Steamboat Springs: Colorado Sun, Mark Jaffe, accessed January 2021, <https://coloradosun.com/2021/01/04/hayden-power-plant-early-closure-colorado/>.
- 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/>.
- Cucinotta D. and Vanelli M., 2020, WHO declares COVID-19 a pandemic: Acta Bio Medica, v. 91, no. 1, 10 March 2020, p. 157-60, <https://www.mattioli1885journals>.
- Daily Record (Cañon City Daily Record), 2020, Florence's LafargeHolcim aims to be first in U.S. to capture carbon on a commercial scale: Cañon City Daily Record, Judith Kohler, 20 October 2020, <https://www.canoncacitydailyrecord.com/2020/10/20/colorado-cement-plant-carbon-capture-project/>.
- Dateline (Dateline Resources), 2020a, Annual report for the financial year ended 30 June 2020: Dateline Resources, <https://www.datelineresources.com.au/asx-announcements/>.
- Dateline, 2020b, September 2020 quarterly report: Dateline Resources, <https://www.datelineresources.com.au/asx-announcements/>.
- Dateline, 2021a, March 2021 quarterly report: Dateline Resources, <https://www.datelineresources.com.au/asx-announcements/>.
- Dateline, 2021b, 2021 annual report for the financial year ended 30 June 2021: Dateline Resources, <https://www.datelineresources.com.au/asx-announcements/>.
- Delecta (Delecta Limited), 2021a, Annual financial report 2021 for the year ended 30 June 2021: Delecta Limited, 72 p., <http://www.delecta.com.au/>.
- Delecta, 2021b, Exploration recommences at REX uranium project: Delecta Limited, ASX announcement, 11 November 2021, <https://www.delecta.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/>.
- DOE (U.S. Department of Energy), 2020a, U.S. Department of Energy Issues LNG Export Approval to Jordan Cove: U.S. Department of Energy, <https://www.energy.gov/articles/us-department-energy-issues-lng-export-approval-jordan-cove>.
- DOE, 2020b, 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, 2020c, Restoring America's competitive nuclear energy advantage, a strategy to assure U.S. national security: U.S. Department of Energy, April 2020, <https://www.energy.gov/strategy-restore-american-nuclear-energy-leadership>, the report is here: <https://www.energy.gov/sites/prod/files/2020/04/f74/Restoring%20America%27s%20Competitive%20Nuclear%20Advantage-Blue%20version%5B1%5D.pdf>
- DOE, 2020d, Secretary Brouillette announces the nuclear fuel working group's strategy to restore American nuclear energy leadership: U.S. Department of Energy, 23 April 2020, <https://www.energy.gov/articles/secretary-brouillette-announces-nuclear-fuel-working-groups-strategy-restore-american>.
- 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>.
- DOLA (Colorado Department of Local Affairs), 2021, Direct distribution of severance tax and federal mineral lease memo: Colorado Department of Local Affairs,

- 30 August 2021, see link to “DLG Memo re: 2021 Direct Distribution,” <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, 2021b, 2020 Production report data, non-coal sites, C.R.S. 34-24-101: Colorado Division of Reclamation, Mining and Safety, accessed December 2021, <https://www.colorado.gov/pacific/drms/data-search>.
- E&E News, 2021, Jordan Cove project dies. What it means for FERC, gas: accessed December 2021, <https://www.eenews.net/articles/jordan-cove-project-dies-what-it-means-for-ferc-gas/>.
- 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, 2020b, 2019 domestic uranium production report: U.S. Energy Information Administration, dated May 2020, 15 p., <https://www.eia.gov/uranium/production/annual/archive/dupr2019.pdf>.
- EIA, 2021a, U.S. crude oil and natural gas proved reserves, year-end 2019, January 2021: U.S. Department of Energy, 45 p., <https://www.eia.gov/naturalgas/crudeoilreserves/pdf/usreserves.pdf>.
- EIA, 2021b, Annual coal report 2020, October 2021: U.S. Department of Energy, 68 p., <https://www.eia.gov/coal/annual/>.
- EIA, 2021c, How much shale (tight) oil is produced in the United States: U.S. Energy Information Administration, accessed December 2021, <https://www.eia.gov/tools/faqs/faq.php?id=847&t=6>.
- EIA, 2021d, Domestic crude oil first purchase prices by area: U.S. Energy Information Administration, accessed September 2021, https://www.eia.gov/dnav/pet/pet_pri_dfp1_k_a.htm.
- EIA, 2021e, Proved reserves of crude oil and natural gas in the United States, Year-End 2019: U.S. Energy Information Administration, January 2021, 45 p., <https://www.eia.gov/naturalgas/crudeoilreserves/pdf/usreserves.pdf>.
- EIA, 2021f, Henry Hub natural gas spot price: U.S. Energy Information Administration, accessed September 2021, <https://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, 2021h, Electricity generation, capacity, and sales in the United States: U.S. Energy Information Administration, website accessed December 2021, <https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php#:~:text=At%20the%20end%20of%202019,solar%20photo-voltaic%20electricity%20generating%20capacity>.
- EIA, 2021i, U.S. energy-related CO2 emissions declined by 11% in 2020: U.S. Energy Information Administration, 12 April 2021, <https://www.eia.gov/todayinenergy/detail.php?id=47496>.
- EIA, 2021j, Colorado state profile and energy estimates, profile analysis: U.S. Energy Information Administration, accessed December 2021, <https://www.eia.gov/state/analysis.php?sid=CO>.
- EIA, 2021k, Annual coal distribution report: U.S. Energy Information Administration, 4 October 2021, <https://www.eia.gov/coal/distribution/annual/>.
- EIA, 2021l, Electric power annual (see Table 1.1): U.S. Energy Information Administration accessed December 2021, <https://www.eia.gov/electricity/annual/>.
- EIA, 2021m, Nuclear explained: U.S. Energy Information Administration, accessed December 2021, <https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php#:~:text=At%20the%20end%20of%20December,is%20about%2038%20years%20old>.
- EIA, 2021n, 2020 Uranium marketing annual report: U.S. Energy Information, 20 May 2021, <https://www.eia.gov/uranium/marketing/>.
- EIA, 2021o, Domestic uranium production report – annual: U.S. Energy Information, website landing page accessed December 2021, <https://www.eia.gov/uranium/production/annual/>.
- 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>.

- Federal Register, 2021b, 2021 Request for information regarding establishment of the Department of Energy uranium reserve program: U.S. National Archives, 11 August 2021, <https://www.federalregister.gov/documents/2021/08/11/2021-17145/request-for-information-regarding-establishment-of-the-department-of-energy-uranium-reserve-program>.
- FERC (Federal Energy Regulatory Commission), 2021, State of the markets 2020: Federal Energy Regulatory Commission, Office of Energy Policy and Innovation, Division of Energy Market Assessments, 18 March 2021, 20 p.
- Fortier, S.M., Nassar, N.T., Lederer, G.W., Brainard, Jamie, Gambogi, Joseph, and McCullough, E.A., 2018, Draft critical mineral list—Summary of methodology and background information—U.S. Geological Survey technical input document in response to Secretarial Order No. 3359: U.S. Geological Survey Open-File Report 2018–1021, 15 p., <https://doi.org/10.3133/ofr20181021>.
- Freeport (Freeport-McMoRan Inc.), 2021a, Form 10-K annual report: Freeport-McMoRan Inc., <https://www.fcx.com/>.
- Freeport (Freeport-McMoRan Inc.), 2021b, Form 8-K: Freeport-McMoRan Inc., dated 21 October 2021, <https://www.fcx.com/>.
- 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>
- 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>.
- IEA (International Energy Agency), 2018a, Cement technology roadmap plots path to cutting CO₂ emissions 24% by 2050: International Energy Agency, 6 April 2018, <https://www.iea.org/news/cement-technology-roadmap-plots-path-to-cutting-co2-emissions-24-by-2050>.
- IEA, 2018b, Technology roadmap, low-carbon transition in the cement industry: International Energy Agency, March 2018, 61 p., <https://www.iea.org/reports/technology-roadmap-low-carbon-transition-in-the-cement-industry>.
- IEA, 2020, Award-winning coal unit set for retirement, IEA Clean Coal Centre, accessed December 2021, <https://www.iea-coal.org/usa-award-winning-coal-unit-set-for-retirement/#:~:text=The%20five%20owners%20of%20a,the%20facility%20will%20be%20shuttered>.
- IEA, 2021, Oil markets face uncertain future after rebound from historic Covid-19 shock: International Energy Agency, 17 March 2021, <https://www.iea.org/news/oil-markets-face-uncertain-future-after-rebound-from-historic-covid-19-shock>.
- LafargeHolcim, 2020, U.S. Department of Energy's National Energy Technology Laboratory announces investment to further develop LH CO₂METN Colorado project, carbon capture technology: Lafarge Holcim, 17 September 2020, <https://www.lafargeholcim.us/us-department-energys-national-energy-technology-lab-ratory-announces-investment-further-develop-lh>.
- Libero (Libero Copper), 2020, Management's discussion and analysis, for the year ended December 31, 2020: Libero Copper, https://www.liberocopper.com/_resources/financials/LBC-MDA-Q4-2020.pdf.
- Libero 2021, Management's discussion and analysis, for the three and six months ended June 30, 2021: Libero Copper, https://www.liberocopper.com/_resources/financials/MDA-Q2-2021.pdf.
- Lien (Pete Lien and Sons), 2021, accessed December 2021, <https://www.petelien.com/>.
- McIntosh, W.C. and Chapin, C.E., 2004, Geochronology of the central Colorado volcanic 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.), 2020, La Plata property overview: Metallic Minerals Corp., accessed December 2020, <https://www.metallic-minerals.com/projects/laplata-1/property-overview/>.
- Metallic Minerals, 2021, Metallic minerals announces start of first phase drilling at La Plata silver-gold-copper project in southwest Colorado, USA: Metallic Minerals Corp., <https://www.metallic-minerals.com/news/2021/metallic-minerals-announces-start-of-first-phase-drilling-at-la-plata-silver-gold-copper-project-in-southwest-colorado-usa/>.
- 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>.
- NETL (U.S. National Energy Technology Laboratory), 2021, NETL Carbon management and oil and gas research project review meeting, integrating CCUS projects and FEED studies, LafargeHolcim CO₂MENT Colorado project FE0031942: presentation by Svante, 3 August 2021, https://netl.doe.gov/sites/default/files/netl-file/21CMOG_CCUS_Jelen.pdf.
- Nelson-Moore, J.L., Bishop Collins, D., Hornbaker, A.L., 1978, Radioactive mineral occurrences of Colorado and bibliography: Colorado Geological Survey Bulletin 40, 1054 p., <https://coloradogeologicalsurvey.org/publications/bibliography-radioactive-minerals-colorado/>.
- Newmont (Newmont Corporation), 2021, Form 10-K annual report: Newmont Corporation, <https://newmont.com/>.

- NRC (U.S. Natural Resources Committee), 2019, Natural resources committee passes mining reform, mining pension bills: U.S. Natural Resources Committee, accessed January 2021, <https://naturalresources.house.gov/media/press-releases/natural-resources-committee-passes-mining-reform-mining-pension-bills>.
- NS Energy, 2021, Profiling the top five largest gold mining companies in the world: NS Energy, 4 May 2021, <https://www.nsenergybusiness.com/features/largest-gold-mining-companies/>.
- O’Keeffe, M.K. and Berry, K.A., 2019, Colorado mineral and energy industry activities 2018-2019: Colorado Geological Survey Information Series 82, 30 p., <https://coloradogeologicalsurvey.org/publications/colorado-mineral-energy-industry-activities-2019/>.
- O’Keeffe, M.K. and Berry, K.A., 2021, Colorado mineral and energy industry activities 2018-2019: Colorado Geological Survey Information Series 83, 32 p., <https://coloradogeologicalsurvey.org/publications/colorado-mineral-energy-industry-activities-2020/>.
- O’Keeffe, M.K., Peretyatko, A.I., and Berry, K.A., 2018, Colorado mineral and energy industry activities 2018-2019: Colorado Geological Survey Information Series 81, 29 p., <https://coloradogeologicalsurvey.org/publications/colorado-mineral-energy-industry-activities-2018/>.
- PCA (Portland Cement Association), 2021, accessed December 2021, <https://www.cement.org/cement-concrete>.
- S&P (S&P Global Market Intelligence), 2021a, Investment fund Sprott turns uranium prices red hot, fund managers say: S&P Global Market Intelligence, 20 September 2021, <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/investment-fund-sprott-turns-uranium-prices-red-hot-fund-managers-say-66637758>.
- S&P (S&P Global Market Intelligence), 2021b, PDAC special edition: world exploration trends 2021: S&P Global Market Intelligence, March 2021, 12 p., <https://pages.marketintelligence.spglobal.com/world-exploration-trends-2021-report-MS.html>.
- S&P Platts (S&P Global Platts), 2021, Colorado, Minnesota resource plans driving Xcel’s carbon-free goal by 2050, April 2021: S&P Global Platts, <https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/042921-colorado-minnesota-resource-plans-driving-xcels-carbon-free-goal-by-2050>.
- 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/>.
- SEC (U.S. Securities and Exchange Commission), 2021, Modernization of property disclosures for mining registrants: a small entity compliance guide: U.S. Securities and Exchange Commission, <https://www.sec.gov/corpfin/secg-modernization-property-disclosures-mining-registrants>.
- SLB (Colorado State Land Board), 2021a, State Land Board income and inventory report, fiscal year 2019-20, annual review of income generated by State Trust lands: Colorado State Board of Land Commissioners, 23 p., <https://slb.colorado.gov/reports>.
- SLB, 2021b, Annual report fiscal year 2019-2020: Colorado State Land Board, 16 p., <https://slb.colorado.gov/reports>.
- Summit Brick Company, 2021, accessed December 2021, <https://www.summitbrick.com/about.html>.
- Svante (Svante, Inc.), 2021, accessed December 2021, <https://svanteinc.com/carbon-capture-technology/>.
- Tumbleweed (Tumbleweed Midstream LLC), 2021, accessed December 2021, <https://www.tumbleweedmidstream.com/ladder-creek-system>.
- 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/>.
- USDR (U.S. Department of Revenue), 2021, Natural resources revenue data: U.S. Department of the Interior, U.S. Department of Revenue, <https://revenuedata.doi.gov/>, accessed August 2021.
- 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, 2021a, Mineral commodity summaries 2021: U.S. Geological Survey, 200 p., <https://pubs.er.usgs.gov/publication/mcs2021>.
- USGS, 2021b, Crushed stone and sand and gravel in the third quarter 2021: 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, 2021d, Minerals yearbook: U.S. Geological Survey, <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 Corporation), 2021a, Silver Cliff, Colorado: Viscount Mining Corporation, accessed 2 December 2021, <https://viscountmining.com/projects/silver-cliff/>.
- Viscount, 2021b, Viscount mining reports reconfirming geophysical and geochemical results at Silver Cliff: Viscount Mining Corporation, 18 May 2021, <https://viscountmining.com/viscount-mining-reports-reconfirming-geophysical-and-geochemical-results-at-silver-cliff/>.
- Viscount, 2021c, Viscount mining finds widespread silver mineralization over 170 meters per hole on multiple drill holes at the Passiflora in Silver Cliff Colorado: Viscount Mining Corporation, 18 May 2021, <https://viscountmining.com/viscount-mining-finds-widespread-silver-mineralization-over-170-meters-per-hole-on-multiple-drill-holes-at-the-passiflora-in-silver-cliff-colorado/>.
- Western Uranium (Western Uranium and Vanadium Corp.), 2021, Western Uranium & Vanadium Corp. 2021 Update: Western Uranium and Vanadium Corp., news release dated 13 January 2021, <https://www.western-uranium.com/newsreleases.html>.
- WNN (World Nuclear News), 2020, Congress approves nuclear energy funding for FY2021: World Nuclear News, 23 December 2020, <https://world-nuclear-news.org/Articles/Congress-approves-nuclear-energy-funding-for-FY202>.
- Zacapa (Zacapa Resources), 2021, Responsible exploration for the new energy economy: Zacapa Resources, November 2021 presentation, https://zacaparesources.com/corporate-presentation/Zacapa_Investor-Presentation.pdf.
- Zephyr (Zephyr Minerals), 2020, Zephyr reports Dawson Gold drilling: Zephyr Minerals, News Release 15-20, 23 September 2020, 2 p., https://5c0801eb-fbe5-4062-9daf-210cdb4cdcb6.filesusr.com/ugd/2f57bf_ef7045cabcf041ccaf4c518d3045deaf.pdf.
- Zephyr, 2021a, Zephyr submits mine permit application: Zephyr Minerals, News Release No. 0-5-21, 5 July 2021, https://www.zephyrminerals.com/_files/ugd/2f57bf_9dcfc07c77a04271a0b77bb701f0d30a.pdf.
- Zephyr, 2021b, Zephyr receives initial tailings characterization data: Zephyr Minerals, News Release No. 03-21, 26 May 2021, https://www.zephyrminerals.com/_files/ugd/2f57bf_b208c014cdad47a9aea0dda6f8954366.pdf.

