

INFORMATION SERIES 82

Colorado Mineral and Energy Industry Activities 2018-2019

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Cover:

Sand and gravel operation along the South Platte River, near Brighton, Adams County. Larry Scott, Colorado Geological Survey
Design and layout by Larry Scott.

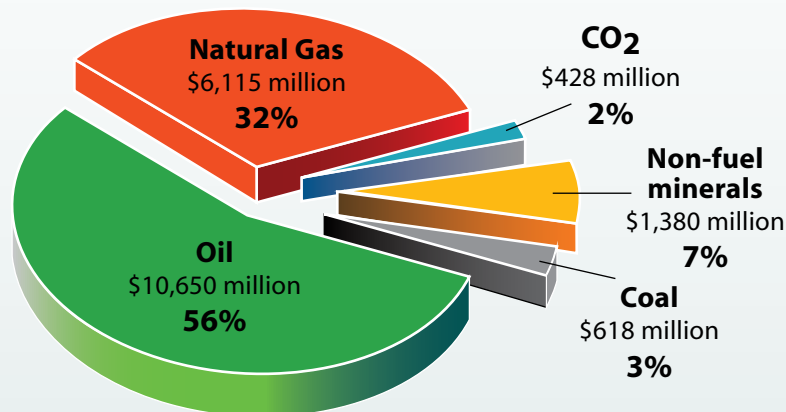
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EXECUTIVE SUMMARY

Colorado produced several mineral and energy-related commodities in 2018. The top commodities produced in Colorado, in terms of production value, include oil, natural gas, coal, industrial gases (carbon dioxide and helium), gold, molybdenum, cement, sand and gravel, and crushed stone. The total value of mineral and energy fuels production in Colorado for 2018 is estimated to be \$19.19 billion. Mineral production values for 2018 are shown by commodity type in **Figure ES-1**. Oil and natural gas production accounted for 87% of Colorado's total mineral and energy production value in 2018. Estimated mineral and energy production values for 1994 through 2018 are shown in **Figure ES-2**.



Total value for 2018: \$19.19 billion

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

The total estimated value of oil and natural gas production in 2018 is \$16.77 billion. Colorado oil and 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. According to the U.S. Department of Energy - Energy Information Agency (EIA), Colorado has the sixth largest reserves of natural gas and eighth largest proven oil reserves in the U.S. The estimated value of Colorado coal production in 2018 is \$618 million. The overall decreasing trend in coal production is due primarily to the increased use of natural gas and renewable energy nationwide. Colorado is the 11th largest coal producer in the U.S. with both underground and surface mines currently in operation west of the continental divide.

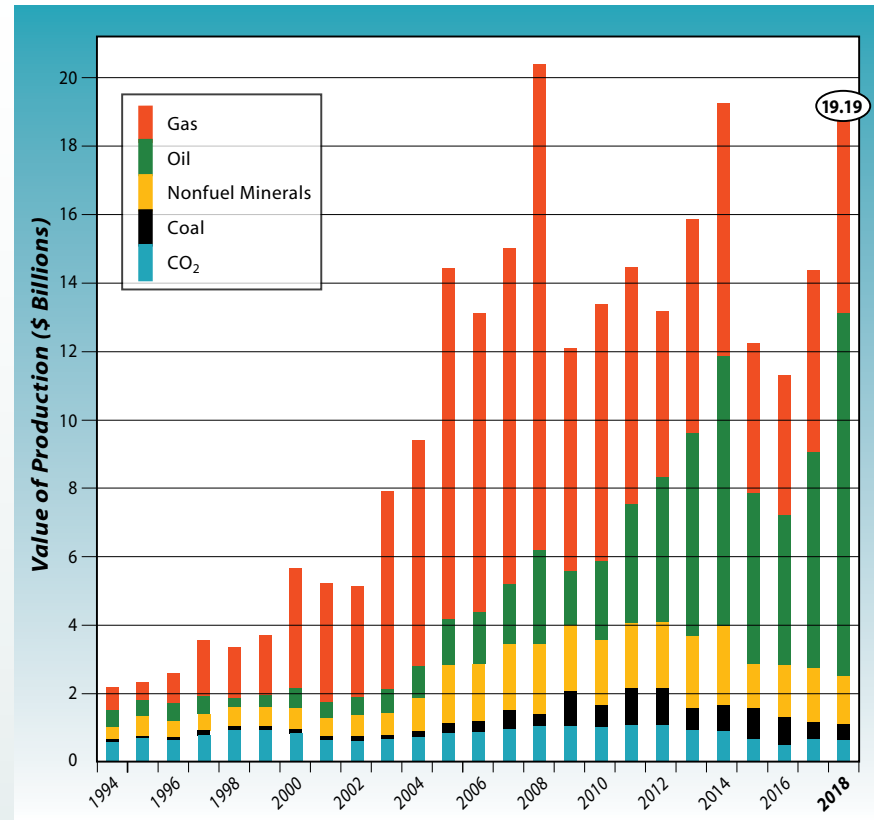


Figure ES-2. Mineral and energy fuel production value in Colorado, 1994–2018.

Nonfuel mineral production includes metals, aggregate (e.g. sand and gravel, crushed stone), and industrial minerals. The United States Geological Survey (USGS) estimates that the total value of Colorado's production of nonfuel minerals in 2018 is \$1.38 billion. Colorado is the third largest gold producer in the U.S. Two Colorado mines continue to produce molybdenum and the state was the second largest producer of this metal in 2018 behind Arizona. Molybdenum is produced as a byproduct during copper mining in Arizona. Although Colorado has been a producer in the past, there was no uranium mining in Colorado in 2018. Continued low uranium prices account for the lack of mining.

As in 2017, 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 2018 is \$428 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. Energy and mining companies that extract these resources pay severance 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 Colorado Geological Survey (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**.

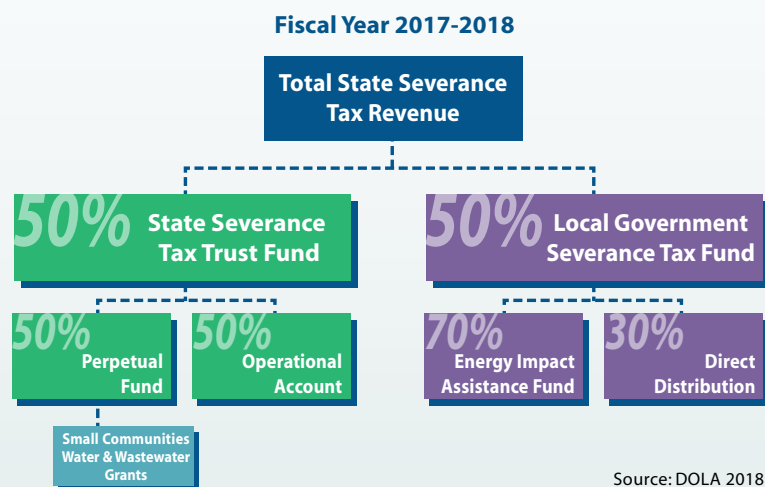


Figure ES-3. Distribution of state severance tax revenue in Colorado.

The Colorado Department of Local Affairs (DOLA) administers the distribution of severance tax revenue to county and local governments. In fiscal year (FY) 2017/2018 (17/18), July 1st through June 30th, Colorado collected \$102.7 million in severance taxes. **Figure ES-4** shows the annual severance taxes collected since 1994. Last fiscal years (FY 2016/2017) low levels of severance tax collections were caused by several factors 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 the last mineral and energy activities report. The map in **Figure ES-5** shows the distribution of severance taxes to each county.

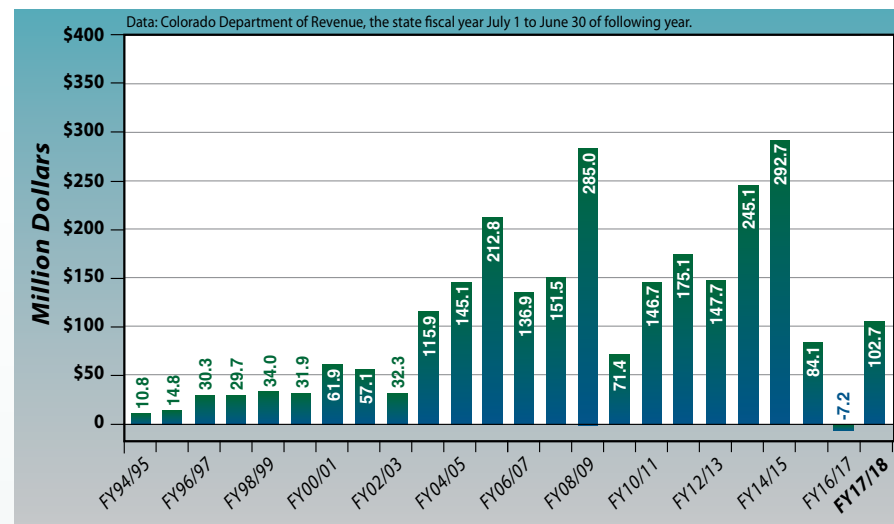


Figure ES-4. Colorado net severance tax collections FY94/95-FY17/18 (NOTE: In FY17/18, severance refunds exceeded collections, hence the negative value).

The State of Colorado owns 2.8 million surface acres and over 4 million mineral estate acres, which are managed by the Colorado State Land Board (SLB). Leasing and royalty revenue from mineral and energy fuel activities on these lands are deposited into the state's Public School Permanent Fund, which was created to help finance public primary education. Funds collected are distributed through the School Finance Act to school districts on a per student basis. A portion of the SLB revenue also goes to the Department of Education's Building Excellent Schools Today (BEST) which is a capital construction program that awards grants to schools. In FY17/18, the SLB received \$103.2 million in mineral revenue. The revenues consisted of the following: oil and natural gas royalties and rentals, \$82.5 million; coal, \$3.6 million; minerals, \$1.8 million; and other revenues, \$15.3 million. **Figure ES-6** shows the SLB revenues from FY 96/97 to FY17/18.

Lands owned by the federal government constitute over 35% of Colorado's acreage. The State of Colorado receives 49% of the rental, royalty, and bonus revenue from mineral and energy fuel leases on federal land. DOLA distributes a portion of these funds to local governments affected by mineral and energy development. In FY18/19, federal mineral lease revenues distributed to county and local governments totaled approximately \$116.7 million. **Figure ES-7** shows the revenue from federal mineral leases from 2009 to 2019.

Severance Tax Distribution by County

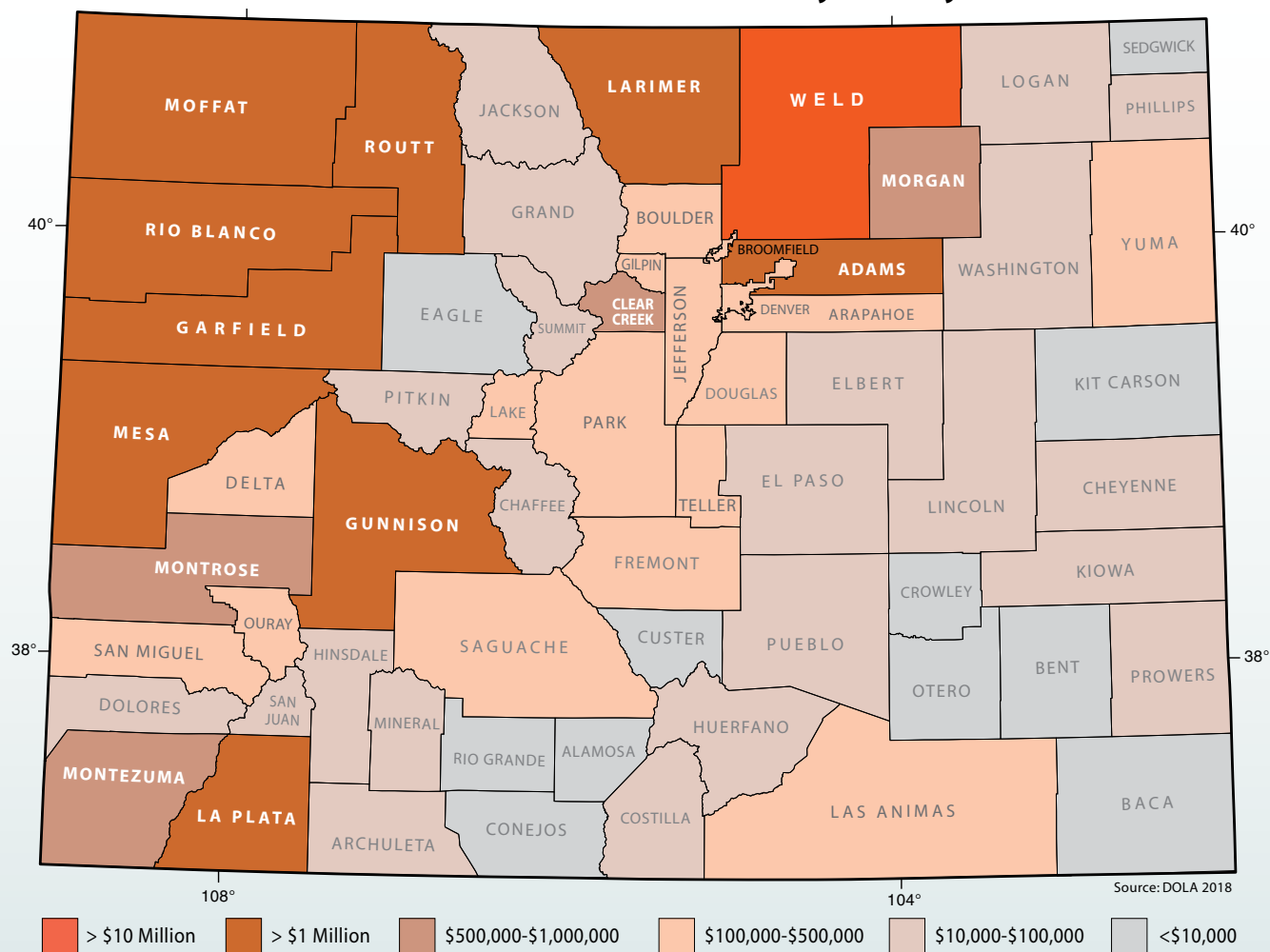


Figure ES-5. Colorado Mineral Severance Tax Distributions by county, FY 18/19.

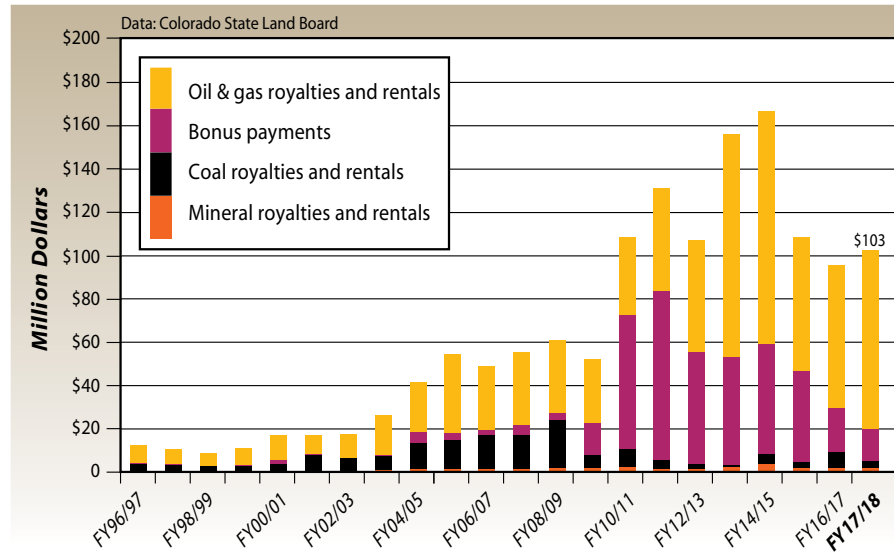


Figure ES-6. Colorado State Land Board (SLB) mineral revenues.

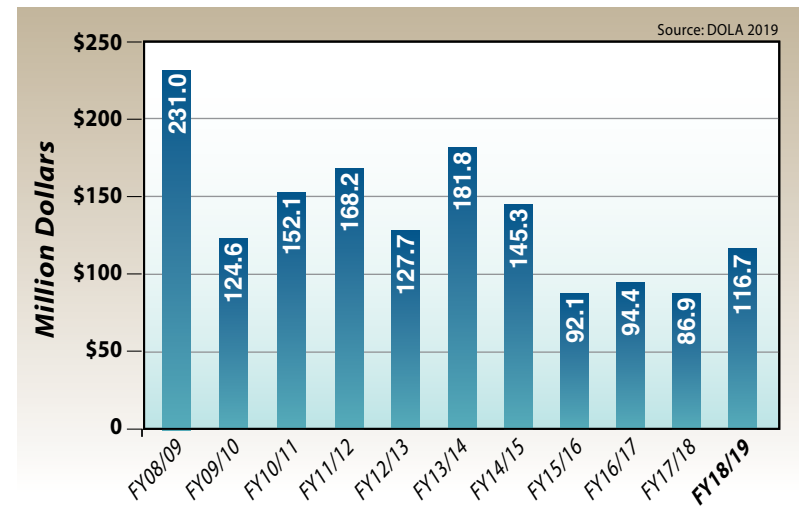


Figure ES-7. Colorado's share of federal mineral lease revenues.



Well operations, southeast of Grover, Weld County. Photo: M. O'Keeffe

CONVENTIONAL ENERGY RESOURCES

Oil and Gas

The map in **Figure 1** shows the major sedimentary basins in Colorado and the location of 2018 oil and natural gas approved drilling permits. Most of the drilling activity and production increases in the last few years are in unconventional reservoirs, especially in the Denver-Julesburg (DJ) Basin of northeastern Colorado. The EIA estimated that about 59% of total U.S. crude oil production in 2018 was from tight oil formations. Hydraulic fracturing and horizontal drilling techniques have allowed these unconventional reservoirs to be produced at a relatively low cost.

Average annual oil prices increased in 2018 to \$59.87 per barrel (EIA Colorado Domestic Crude Oil First Purchase Price) from an average of \$46.41 in 2017. The estimated overall oil production value in 2018 for Colorado is \$10.65 billion (**Figure 2**). This total value is the highest on record and is due to an increase in production as well as an increase in oil prices. Estimated oil production in Colorado between 2017 and 2018 increased by over 40,000 barrels. Oil production in Colorado and the average annual price per barrel over time are shown in **Figure 3**.

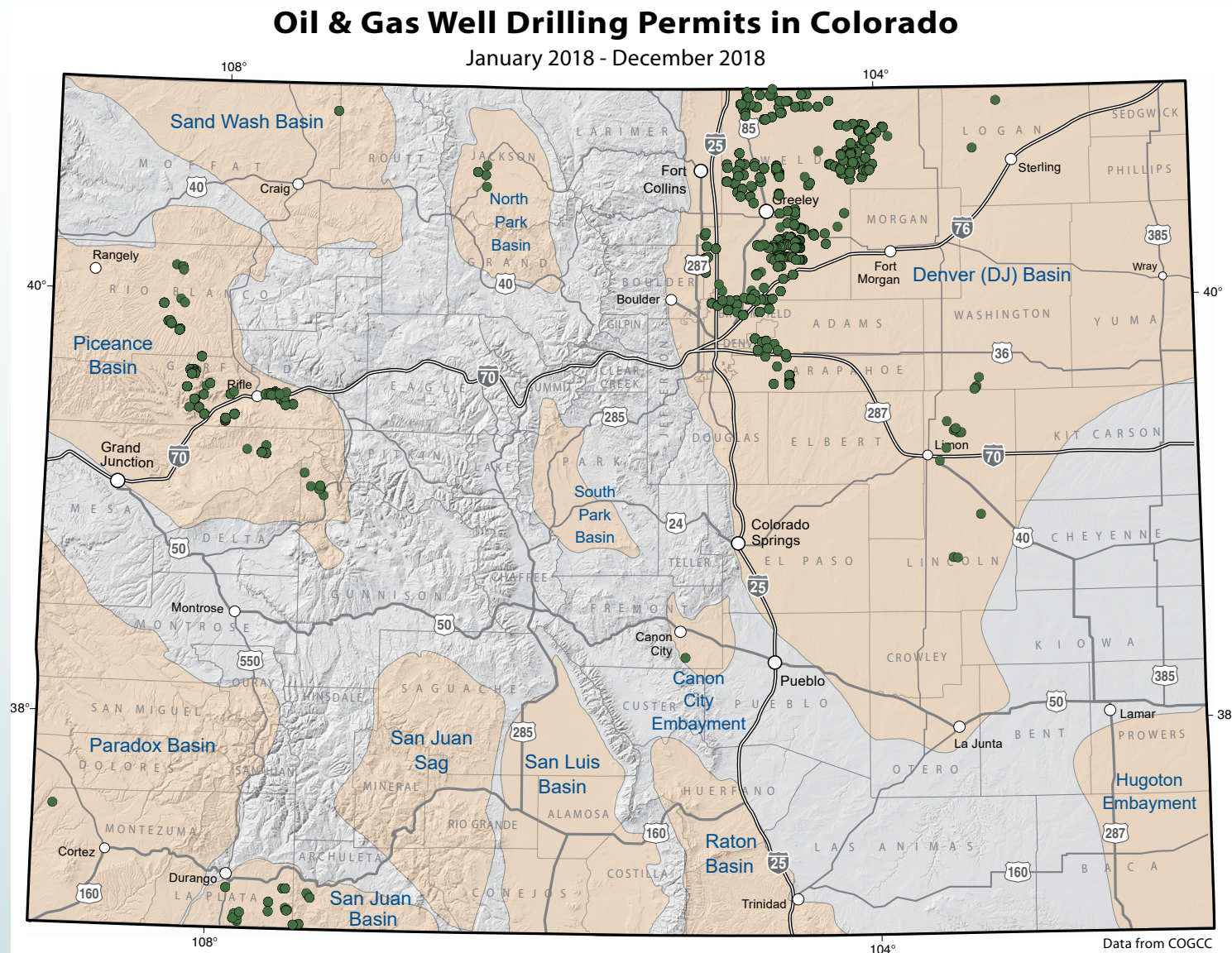


Figure 1. Map of sedimentary basins and the location of oil and gas well drilling permits from January 2018 to December 2018.

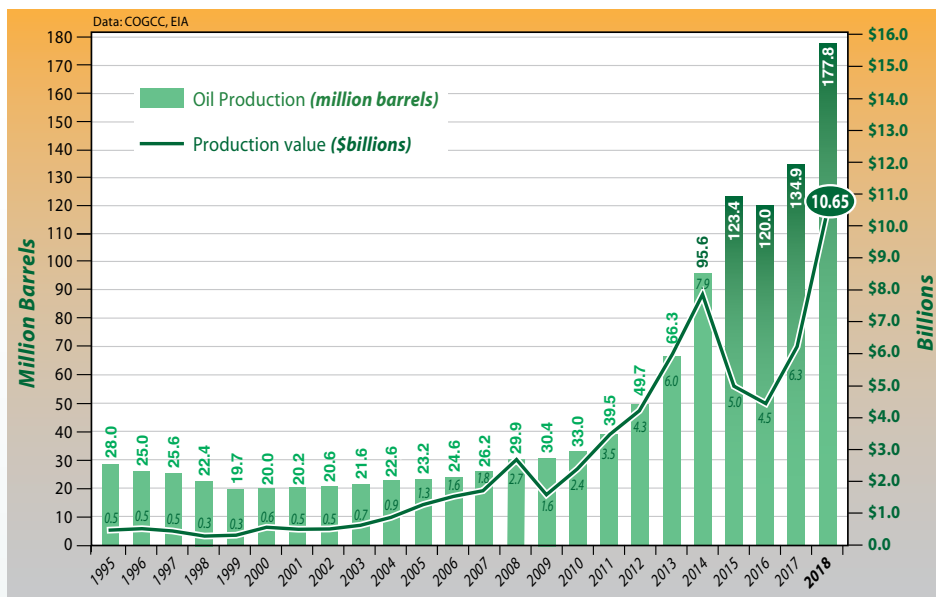


Figure 2. Oil production and estimated production value in Colorado, 1995–2018.

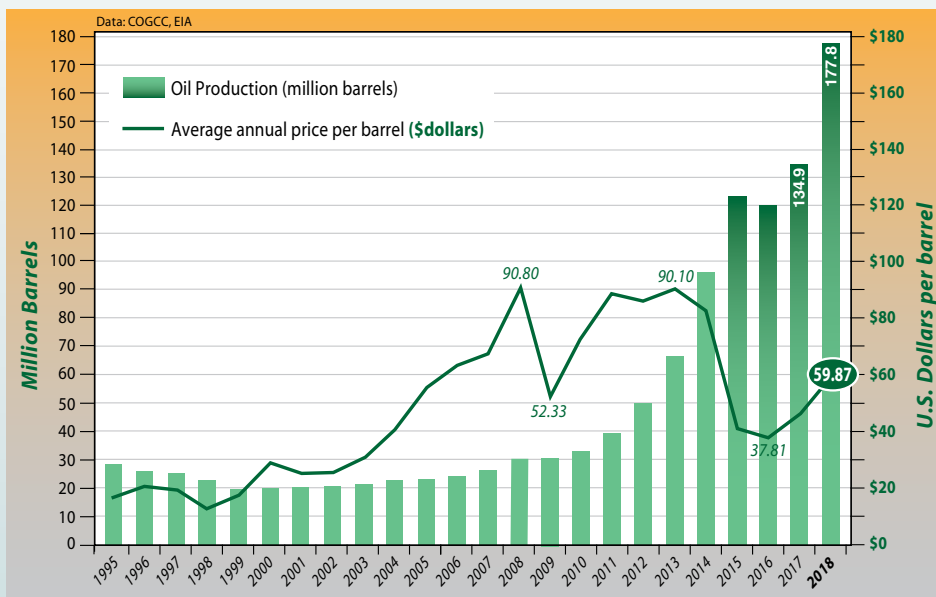


Figure 3. Colorado oil production and average annual price per barrel, 1995–2018.

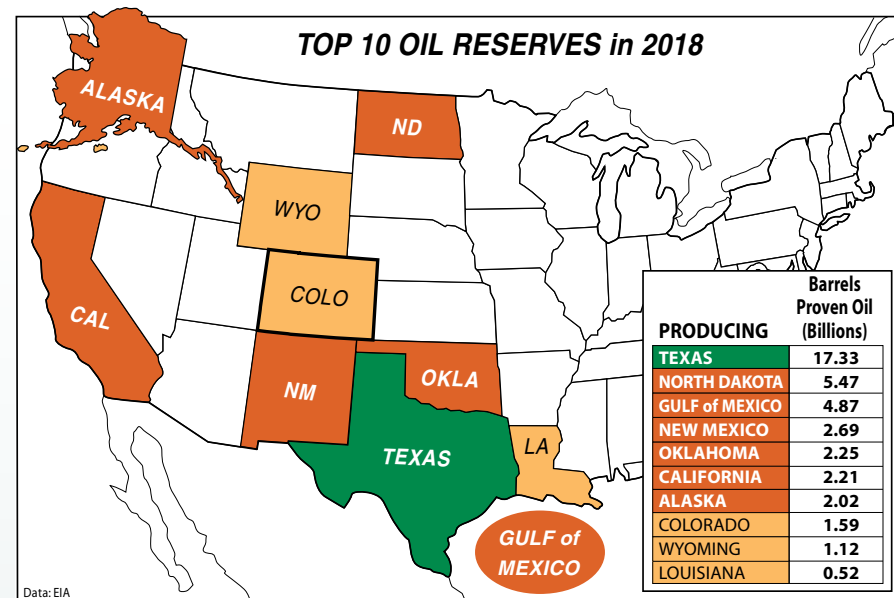


Figure 4. Top 10 states with proven oil reserves in 2017.

At the end of 2017, Colorado ranked eighth among the top ten states with proven oil reserves with an estimated 1.593 billion barrels of oil (BO) (Figure 4).

The 2018 average spot price for natural gas was \$3.27 per thousand cubic feet (Mcf) (based on a heat content of 1.037 British Thermal Units per Mcf) (Figure 5). U.S. natural gas production generally increased between 2008 and 2018 which is consistent with the general decrease in price. The estimated total 2018 natural gas production value in Colorado is \$6.12 billion. In 2017, Colorado had proven natural gas resources of 28,727 billion cubic feet (Bcf), which was the sixth largest in the U.S. (Figure 6).

As presented in previous CGS Mineral and Energy Industry Activity (MEIA) reports, the USGS released an updated 2016 Mancos Shale oil and gas potential assessment for the Piceance Basin located in central and northwestern Colorado. The report states that the Piceance Basin contains undiscovered and technically recoverable resources of 66 trillion cubic feet (Tcf) of natural gas, 74 million BO, and 45 million barrels of natural gas liquids. In 2018, the House Natural Resources Committee held a hearing to discuss the possibility of exporting natural gas from the Piceance Basin in Colorado through the proposed Jordan Cove Energy and Pacific Connector Gas Pipeline. This project would connect the resources from the Piceance Basin via pipeline to international markets thru a proposed liquefied natural gas (LNG) export terminal in Oregon. A draft

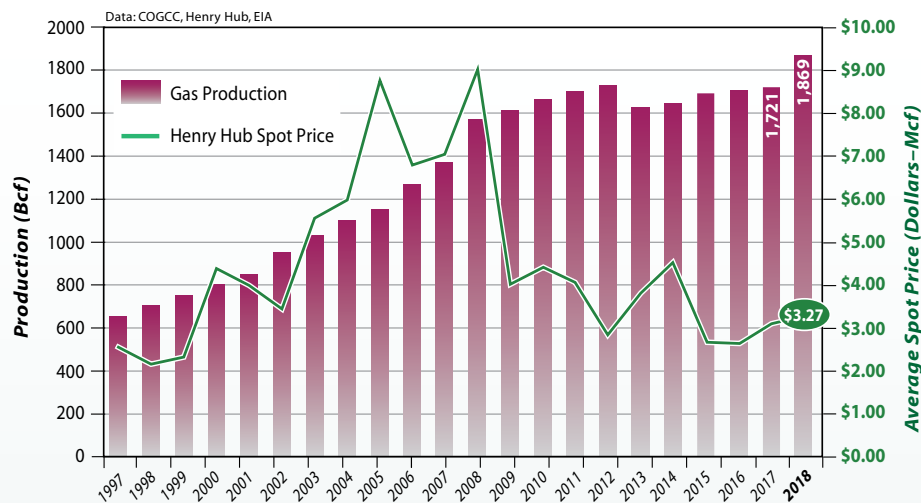


Figure 5. Colorado natural gas production and average price, 1997-2018.

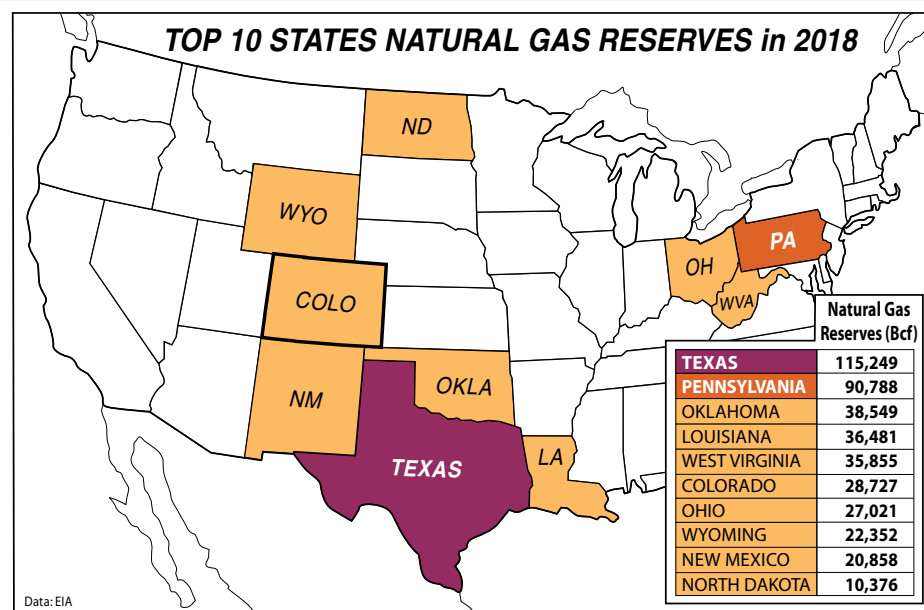


Figure 6. Top 10 states with proven natural gas reserves in 2018 (years end).

environmental impact statement for the project was released for public comment in March 2019 by the Federal Energy Regulatory Commission.

Coalbed Methane

Figure 7 shows the annual coalbed methane production versus conventional natural gas over time. Coalbed methane production reached its highest levels, 59%, of all natural gas production during 1998. Production continuously declined to about 15% of all natural gas production (279 Bcf) in 2018. This decline is largely due to the increase of production of unconventional reservoirs by the utilization of horizontal drilling and hydraulic fracturing techniques.

County Rankings – Oil and Natural Gas Production

Thirty-seven of Colorado's 64 counties currently produce crude oil and/or natural gas. 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 2017 "Colorado First Purchase" price of \$59.87 per BO for the average annual price of oil and the average spot price for natural gas of \$3.27 per Mcf. The total 2018 estimated oil and natural gas production value for Colorado is \$16.765 billion. Figure 8 shows the estimated total oil and natural gas production value by county.

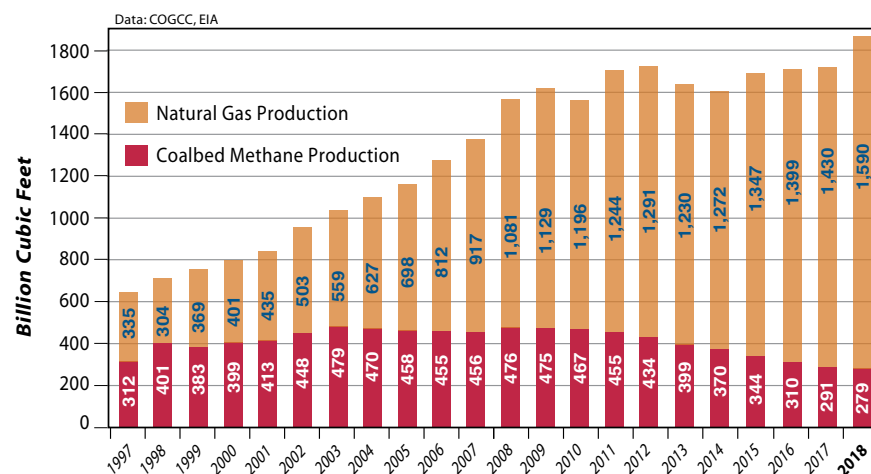


Figure 7. Coalbed methane vs. non-coalbed natural gas production in Colorado, 1997-2018.

Weld County is the single largest producer of oil and natural gas in Colorado with an estimated total production value of about \$12.13 billion. Garfield County has the second largest natural gas and oil production value with an estimated total of \$1.70 billion. La Plata County ranks third in natural gas and oil production value with an estimated total of \$966 million. Rio Blanco, Larimer, and Mesa counties have a combined oil and natural gas production value of \$865 million. **Figures 9 and 10** show the estimated oil and natural gas production by county for 2018, respectively.

Drilling Permits

Most new oil and natural gas drilling permits are still centered in Weld County, with lesser amounts in other oil and natural gas producing counties. Colorado Oil and Gas Conservation Commission (COGCC) data indicate 4,429 drilling permits were approved in 2018, a 24% increase from 2017. **Figure 11** shows the number of annual oil and natural gas drilling permits in Colorado from 1994 to 2018.

Oil Shale

As reported in 2017, more than half of the world's known oil shale resources are located in the Eocene-age Green River Formation, which covers about 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

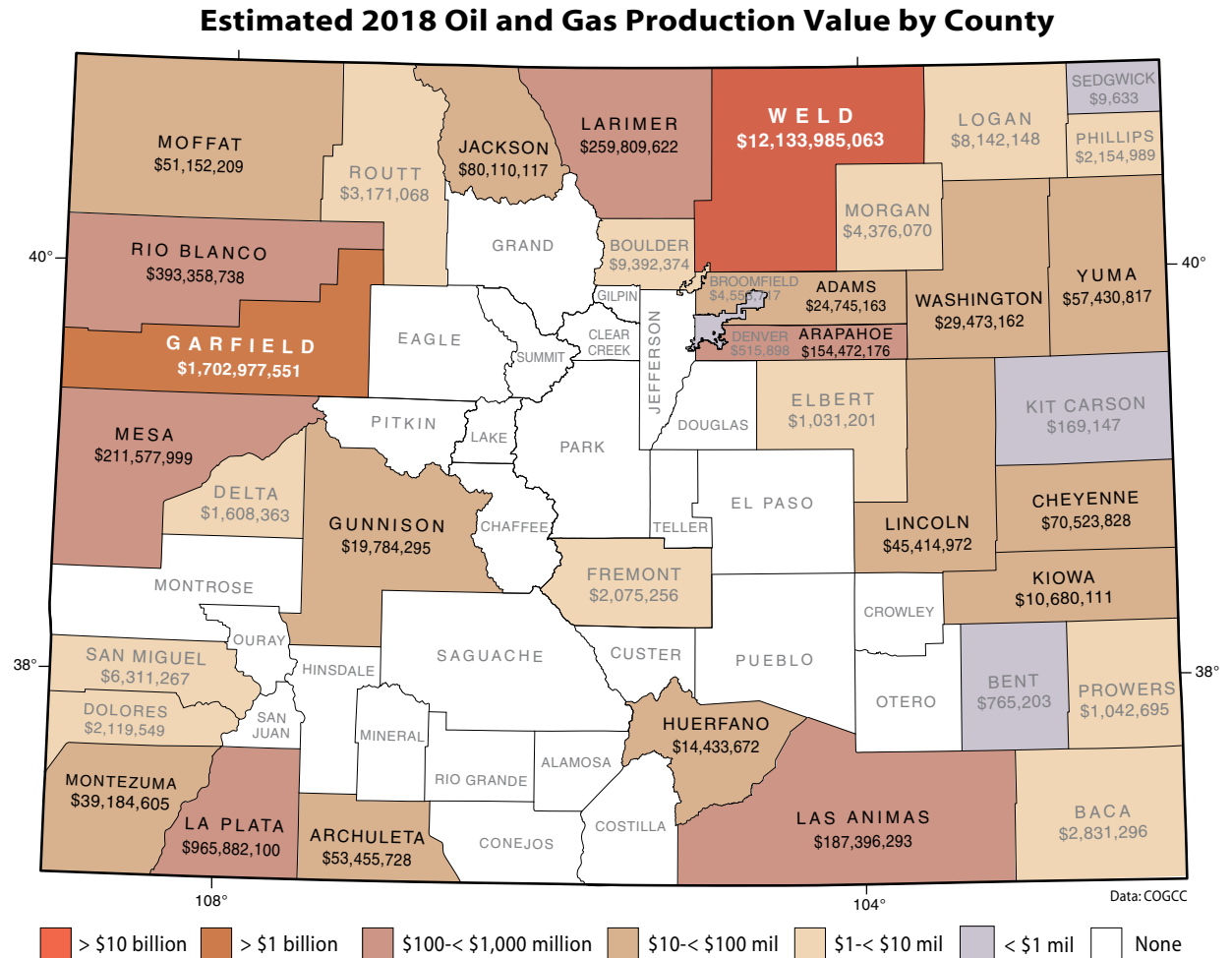
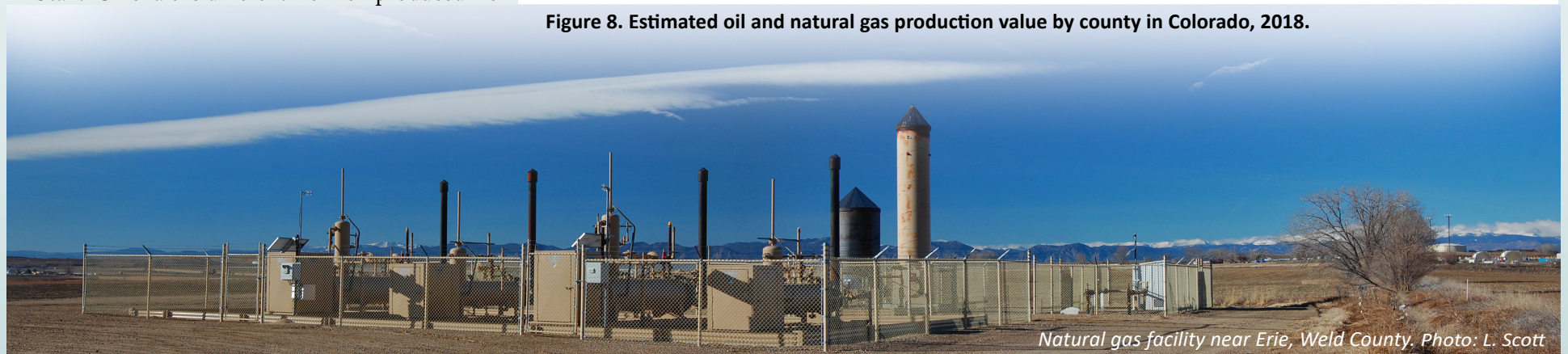
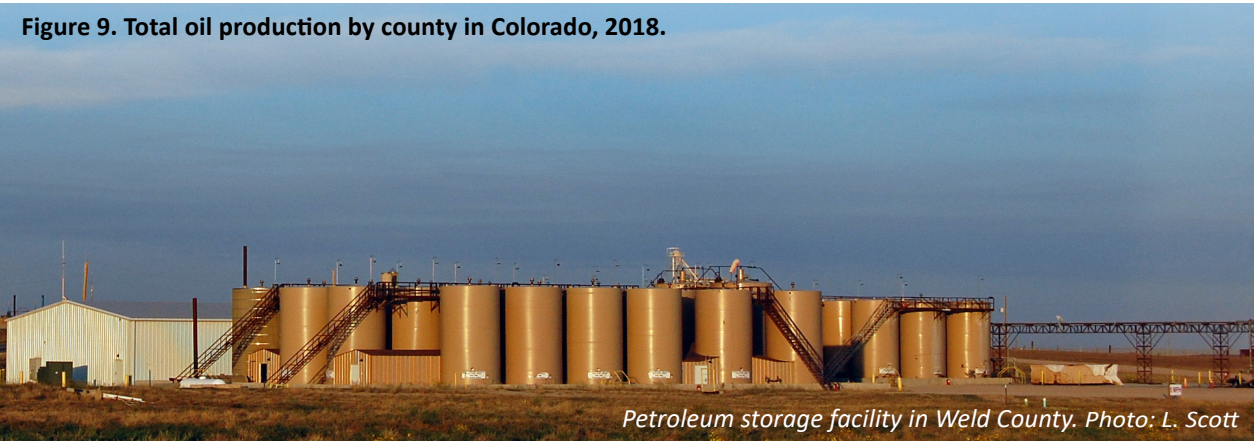


Figure 8. Estimated oil and natural gas production value by county in Colorado, 2018.



Natural gas facility near Erie, Weld County. Photo: L. Scott

In 2018, the COGCC re



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flowline design, construction, testing, operation and maintenance, decommissioning, and the development of new flowline reporting forms. Flowlines are pipes that transfer oil, gas, or condensate from the wellhead. Also, the COGCC adopted new rules for: the setback of new oil and gas wells and production facilities from school or child care centers, inclusive of their outdoor areas; and notification requirements to schools and school districts within a ¼-mile of proposed oil and gas locations.

In 2019, Senate Bill (SB) 19-181 was passed which requires the COGCC to place more emphasis on public and environmental health and safety, as well as addressing cumulative impacts from oil and gas activities. Additionally, the new law shifts the agency's mission from fostering the responsible development of oil and gas resources to minimizing adverse impacts. This includes the following as stated in the Colorado Revised Statutes (C.R.S.):

2018 Natural Gas Production (bcf) by County

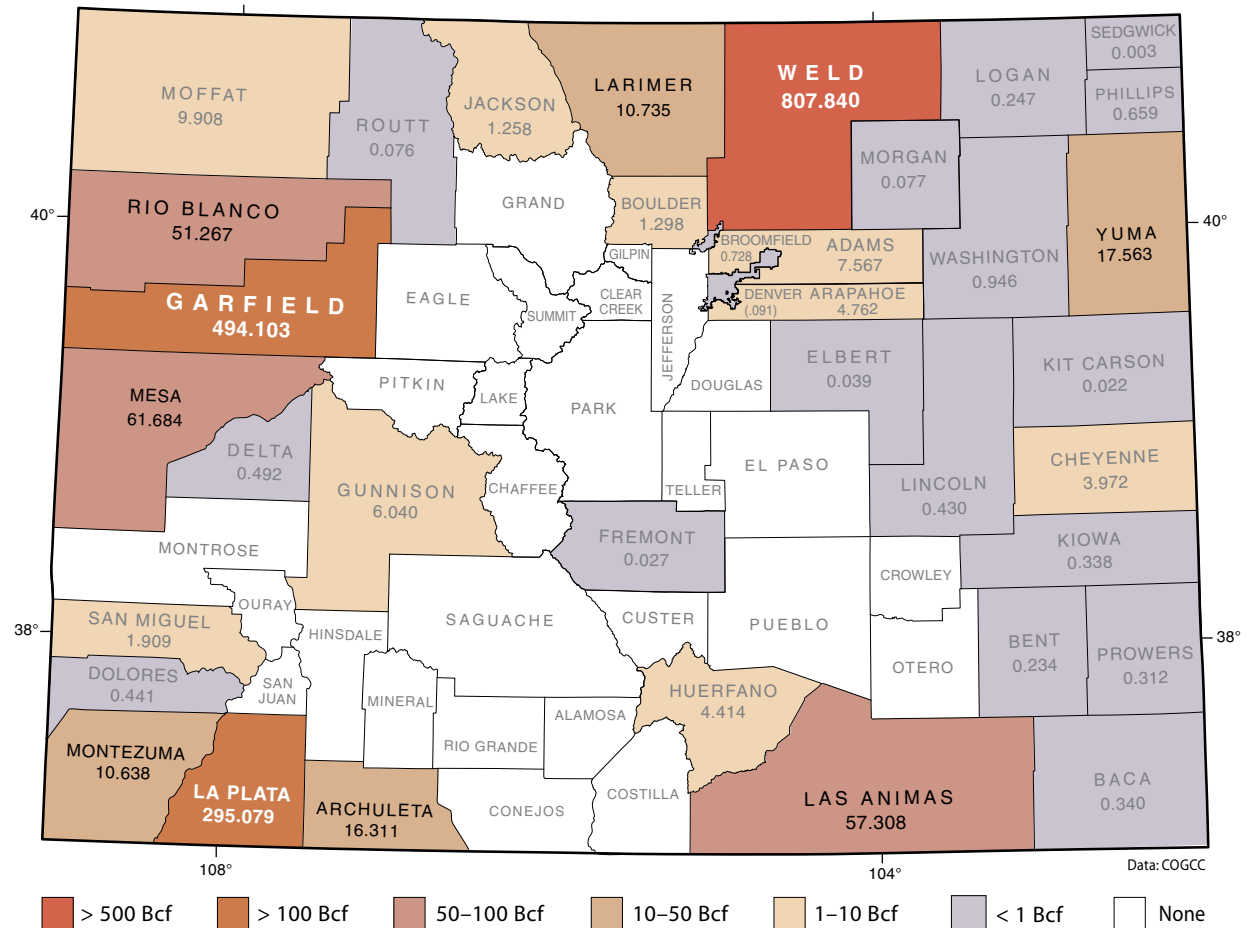
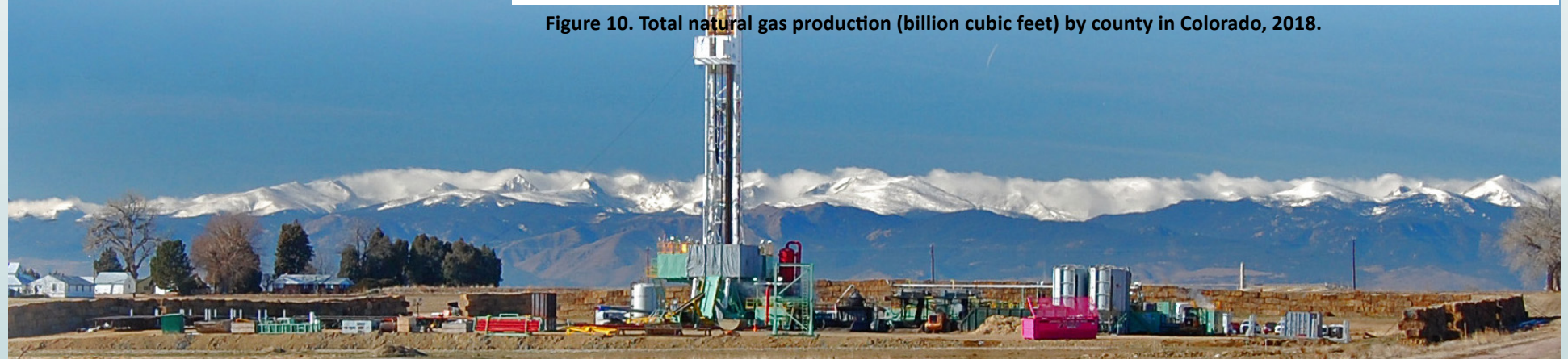


Figure 10. Total natural gas production (billion cubic feet) by county in Colorado, 2018.



“...the commission shall regulate oil and gas operations in a reasonable manner to protect and minimize adverse impacts to public health, safety, and welfare, the environment, and wildlife resources and shall protect against adverse environmental impacts on any air, water, soil, or biological resource resulting from oil and gas operations (C.R.S 34-60-106).”

Other changes to the COGCC include adding a commissioner with public health expertise, developing new criteria with public comment to determine if a proposed operation location requires additional analysis, and developing methods on how the COGCC will work with local governments. The COGCC is currently working on rule and policy changes associated with implementing SB19-181.

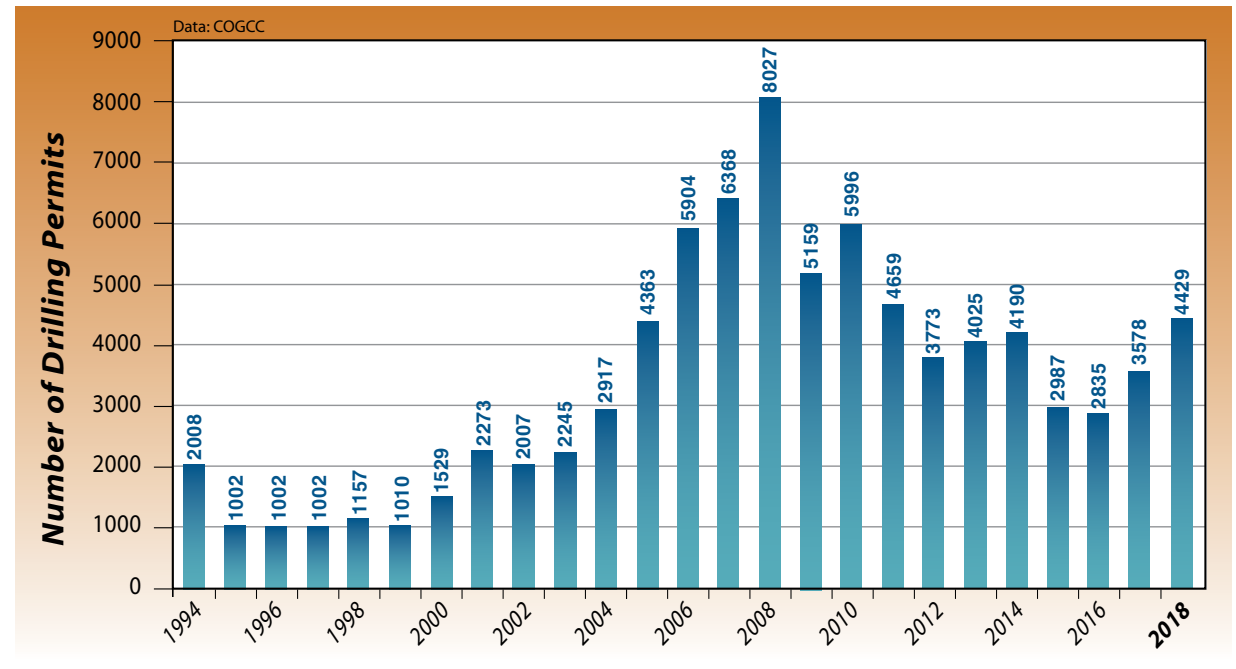


Figure 11. Annual oil and gas drilling permits in Colorado, 1994-2018.



CONVENTIONAL ENERGY RESOURCES: COAL

Colorado coal continues to be a major source of the state's electrical power. According to the EIA, 40% of the electricity generated in Colorado in 2018 came from coal, 37% from natural gas, and 23% from renewables (e.g. wind, hydroelectric, and solar). For comparison, in 2015, 60% of the electricity generated in Colorado came from coal and 22% from natural gas indicating a move away from energy production from coal. As reported last year, the decline of the use of coal for electricity generation is due to federal greenhouse gas regulations and taxes designed to cut carbon dioxide emissions, lower natural gas prices, and the declining costs and growing use of renewable energy sources.

Across the U.S., a record number of coal-fired power plants have been converted to natural gas. According to the EIA, between 2010 and 2019, more than 546 coal-fired power units were retired in the U.S. totaling about 102 gigawatts (GW - one billion watts) of generating capacity. For comparison, at the end of 2018, the U.S. had about 1,097 GW of total electricity generating capacity. The EIA reports that 2018 had the second highest annual total, following 2015, for U.S coal-fired unit retirements.

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. Between 2012 and 2013, the Arapahoe Station in Denver, the Clark Plant in Cañon City, and the Cameo power plant near Grand Junction were shut down. As reported last year, Xcel Energy (Xcel) converted the last remaining coal-fired unit at the Cherokee Generating Station in Denver to natural gas in 2017. Also, in 2017, Xcel announced an agreement to retire two of its three coal-burning units at the Comanche Generation Station in Pueblo between approximately 2022 (Unit 1) and 2025 (Unit 2). In 2019, The Tri-State Generation and Transmission Association officially retired the 100-megawatt Nucla Station power plant as part of an agreement with CDPHE and others associated with the Colorado Visibility and Regional Haze State Implementation Plan.

Coal production from Colorado mines in 2018 is 14.28 million tons. The estimated value of Colorado coal production in 2018 was \$618 million (**Table 1** and **Figure 12**) and the estimated average value of a ton of Colorado coal was \$43.30. Colorado coal production and average prices since 2004 are shown in **Figure 13**. In 2018, 1,160 coal miners were employed in Colorado (**Figure 14**). Colorado has some of the cleanest burning coal in the U.S. and over half of the coal produced is sold outside of Colorado. Previous MEIA reports include summary information about Colorado's coal quality compared to other regions. In 2018, Colorado was ranked 11th in coal production in the U.S. (**Figure 15**) down from 10th in 2017.

Table 1. Coal production, price, value, and employment, 2001–2018.

Xcel Energy Cherokee Generating Station in Denver converted to natural gas in 2017.



Year	Production Tons (Millions)	Colorado Average Annual Coal Price \$/Ton	Product Value (Millions)	Coal Miner Employment
2001	33.41	\$17.20	\$575	1,761
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

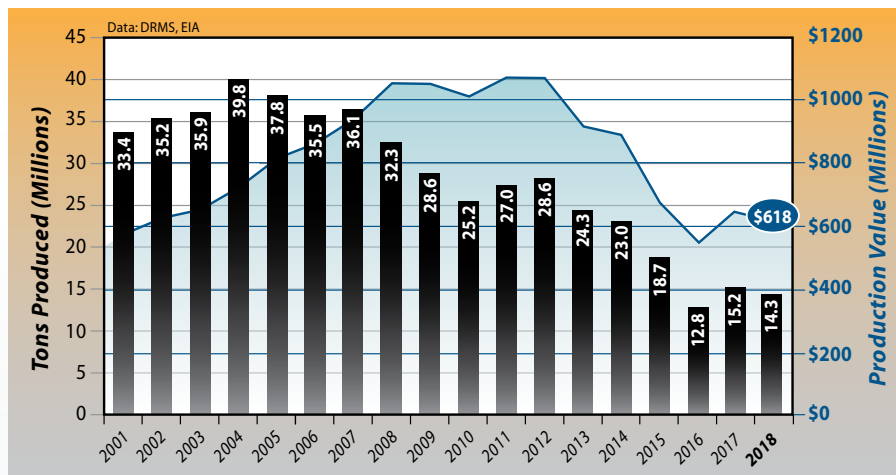


Figure 12. Production and value of coal mined in Colorado, 2001–2018.

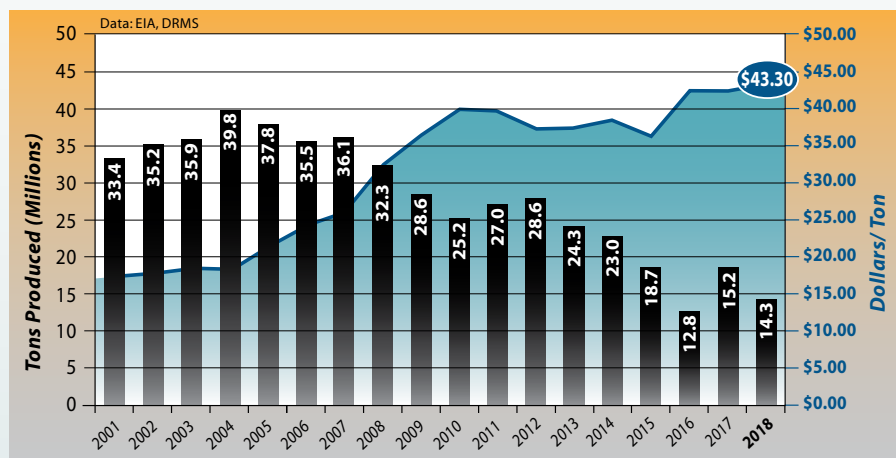


Figure 13. Coal production and average yearly coal price in Colorado, 2001–2018.

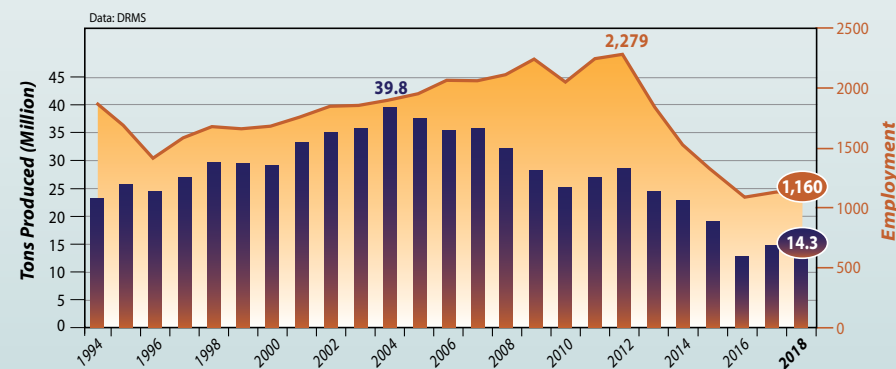


Figure 14. Coal production and employment in Colorado, 1994–2018.

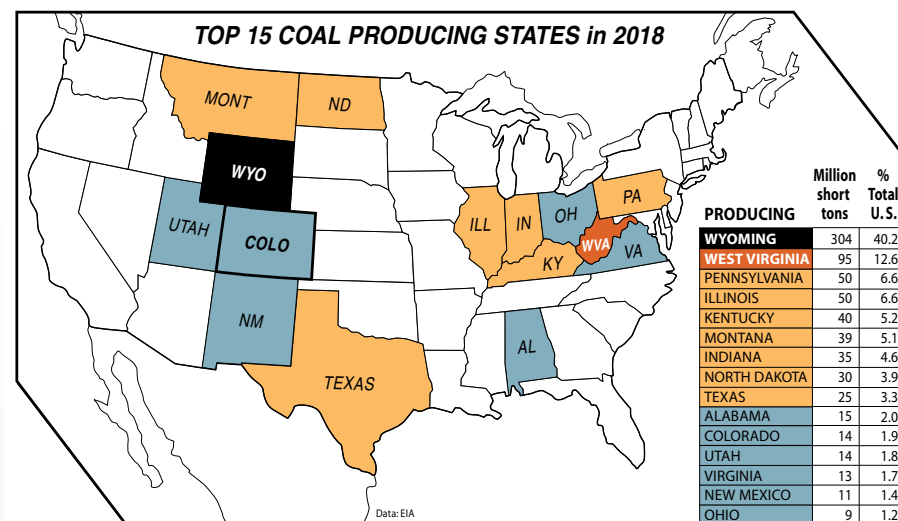


Figure 15. Top 15 coal producing states in 2018 (years end).

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, and coal types and regions are shown on Figure 16.

Six Colorado coal mines were active in 2018, one less than in 2017 as the New Horizon North Mine was idle in June 2017 and stopped production around that time (Table 2). In 2018, Colowyo Mine in Moffat County was preparing to start mining operations at their Collom Pit which could extend the mine life over 30 years. Also, in early 2019, the U.S. Office of Surface Mining Reclamation and Enforcement (OSMRE) approved expansion of the West Elk Mine located in Gunnison County; however, a federal judge recently blocked the expansion due to lawsuits.

Table 2. Active coal mines in Colorado, 2018.

Mine	Operator	County	Mine Type	2018 Prod. (tons)
Bowie #2	Bowie Resources Ltd.	Delta	Underground	idle
Colowyo	Colowyo Coal Co. L.P.	Moffat	Surface	1,470,896
Deserado	Blue Mountain Energy	Rio Blanco	Underground	2,362,251
Foidel Creek	Twentymile Coal Co./Peabody	Routt	Underground	3,049,509
King II	GCC Energy National King Coal LLC.	La Plata	Underground	614,714
Trapper Strip	Trapper Mining Co.	Moffat	Surface	2,141,890
West Elk	Mountain Coal Co./Arch Coal	Gunnison	Underground	4,643,374
Total				14,282,634

Data: DRMS

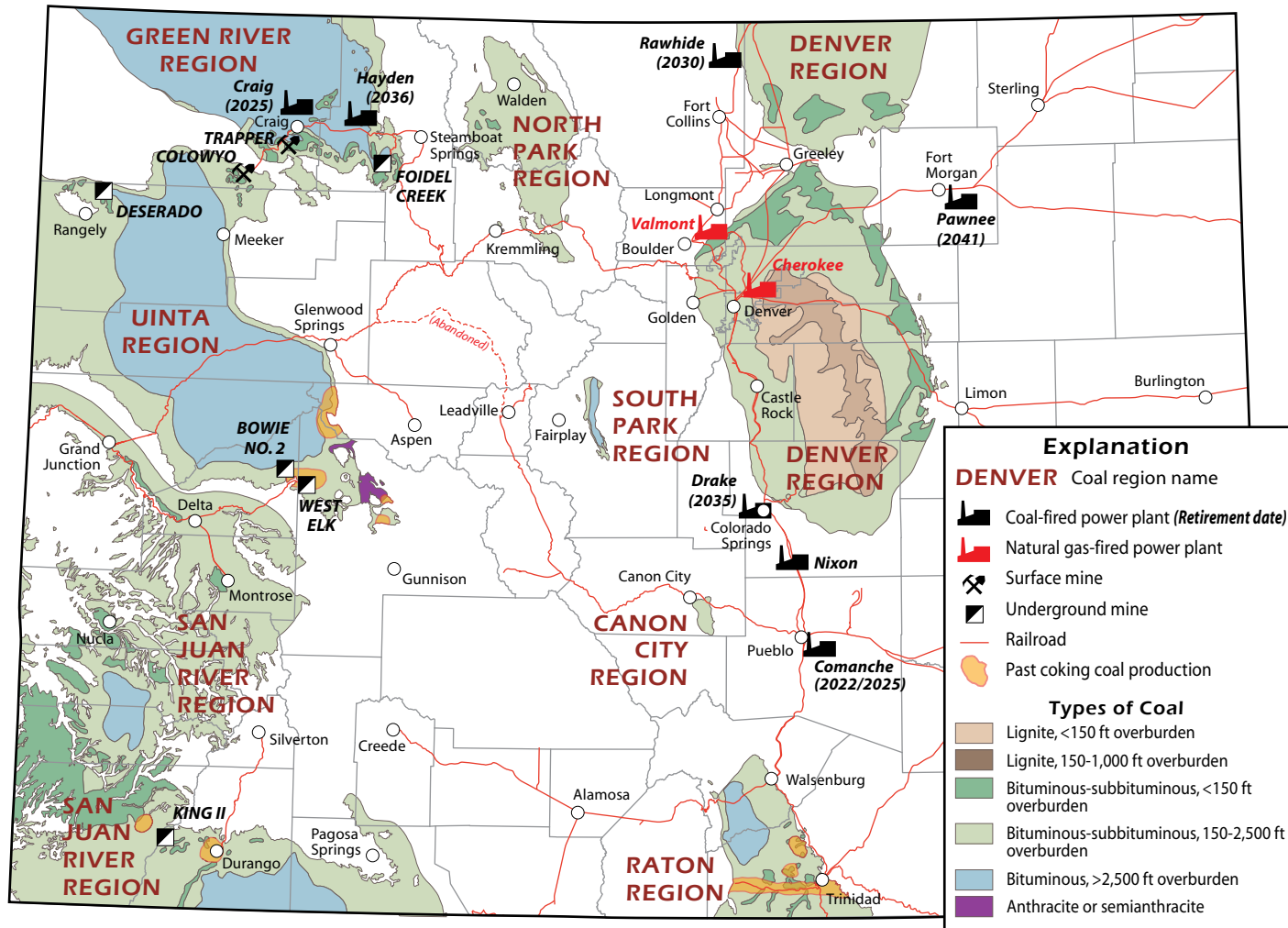


Figure 16. Locations of active coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2018. Dates in parenthesis are estimated closure dates for given power plants.



CONVENTIONAL ENERGY RESOURCES: URANIUM

According to the EIA, nuclear energy accounted for 19.3% of U.S. electricity production in 2018. Colorado is one of about twenty states that did not generate electricity from nuclear energy. At the time of this report, the EIA reports that there are 58 nuclear power plants with 96 nuclear reactors operating in 29 states. Two new nuclear reactors are currently under construction in Georgia.

Figure 17 shows the average annual uranium prices in the U.S. since 2002. As reported last year, prices have been generally trending downward since 2007 and after the 2011 Fukushima nuclear power plant accident in Japan. **Figure 18** shows the estimated annual production of uranium concentrate in the U.S. between 1996 and 2018. Although Colorado has been a producer of uranium in the past, there are currently no producing uranium mines or mills in Colorado. At the end of 2018, uranium was produced from one mill in Utah, four in-situ leaching operations in Wyoming, and one in-situ leaching operation in Nebraska. The proposed Pinon Ridge uranium mill located in Montrose County is still on hiatus due to a 2018 court ruling.

In early 2019, a federal judge lifted a ban on some uranium leases in southwest Colorado. According to the Department of Energy (DOE), Office of Legacy Management, the DOE is restarting uranium-rich property leasing on public lands as it did in 2008. The uranium leasing program would provide leases on uranium properties in the Uravan Mineral Belt area, a uranium-rich area located in southwestern Colorado.

In 2018, about 90% of uranium purchased and delivered to U.S. civilian nuclear power reactors came from other countries including: Canada (26%), Kazakhstan (22%), Australia (20%), Russia (15%), and Uzbekistan (7%). The USGS listed uranium as a critical mineral in 2018. A critical mineral was defined as a non-fuel mineral or mineral material essential to the economic and national security of the U.S., the supply chain of which is vulnerable to disruption and, that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security. In 2018, the U.S. Secretary of Commerce launched an investigation to determine if the current situation associated with uranium imports could potentially impair national security. The conclusion of the investigation indicated that U.S. uranium imports may impair national security. In July 2019, a presidential memorandum was issued indicating some disagreement between the Secretary of Commerce's opinion and the President with regards to uranium production and threats to national security. The memorandum ordered the establishment of the U.S.

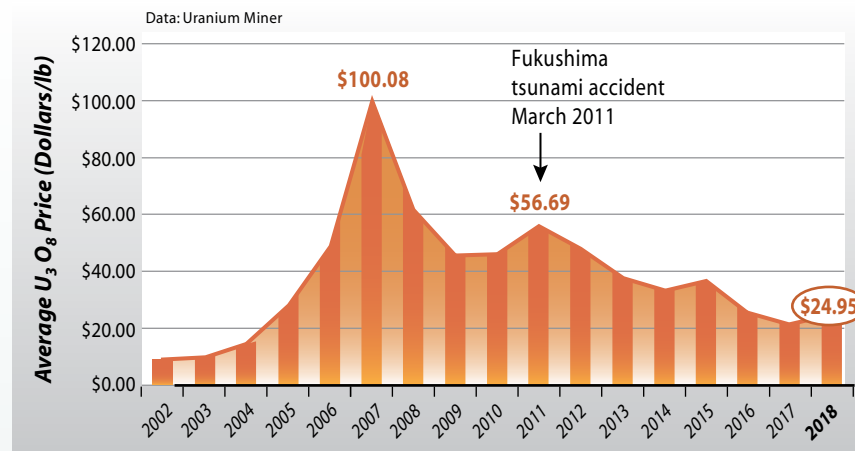


Figure 17. Average annual Triuranium Octoxide (U₃O₈) price per pound in U.S., 2002-2018.

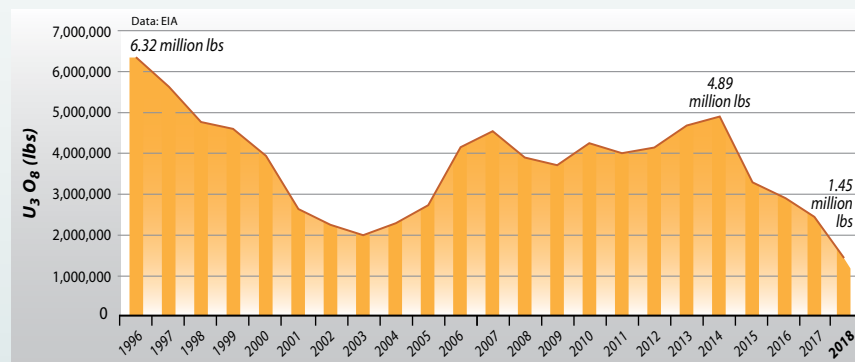


Figure 18. Annual production of uranium concentrate in U. S., 1996-2018.

Nuclear Fuel Working Group “to develop recommendations for reviving and expanding domestic nuclear fuel production.” The memorandum also ordered this working group to submit a report within 90 days with recommendations concerning domestic nuclear fuel production. Additional information associated with uranium and vanadium properties is discussed in the Other Exploration and Development Activities section of this report.

NON-FUEL MINERAL RESOURCES

Non-fuel mineral resources include metals, industrial minerals, and construction materials (e.g. cement, lime, sand, and gravel). The USGS reports that the total U.S. 2018 nonfuel mineral production value was \$82.2 billion, a 3% increase from last years revised total of \$79.7 billion. Colorado ranked 21st in U.S. nonfuel mineral production value and produced an estimated \$1.38 billion, or about 1.68% of the estimated total U.S. production value. **Figure 19** shows the estimated nonfuel mineral production value in Colorado over time.

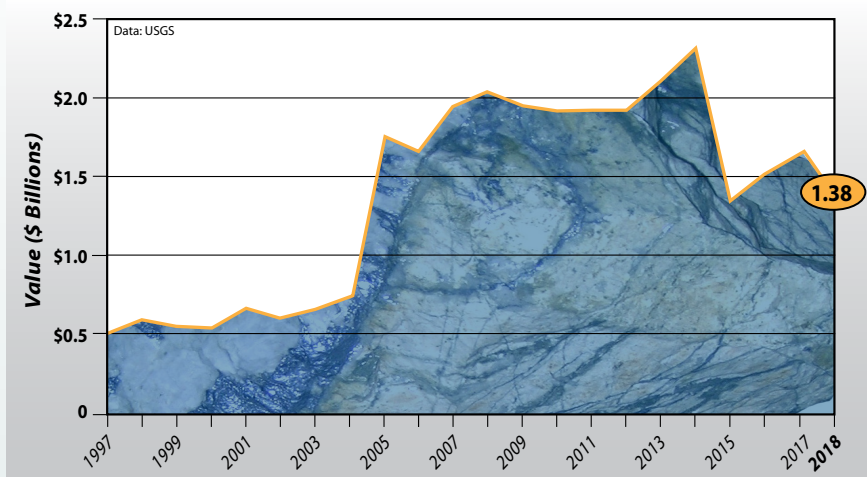


Figure 19. Total nonfuel mineral production value in Colorado, 1997–2018.

Metal Mining

Metals mined in Colorado include gold, molybdenum, and silver. The CGS estimates that the 2018 production value of gold and molybdenum in Colorado is \$875 million. Silver production values for Colorado were unavailable.

Molybdenum

Molybdenum is primarily used to produce engineering steels (e.g. superalloys, nickel alloys, and tool steels), stainless steel, molybdenum metal and other alloys, catalysts, pigments, corrosion inhibitors, smoke suppressants, lubricants, and chemicals. According to the USGS, the U.S. is the third largest producer of molybdenum in the world and produced an estimated 92 million pounds in 2018, valued at an estimated \$1.1 billion, based on average prices reported by the

USGS. This is approximately 3.2% higher than the 2017 estimated production of 89.7 million pounds and was likely due to higher prices. China is the top producer (estimated 287 million pounds in 2018) and Chile is the second largest producer (estimated 134 million pounds in 2018).

Colorado's annual production and the average annual price per pound for molybdenum trioxide (MoO_3) are shown in **Figure 20**. Higher production in Colorado was mainly due to higher molybdenum prices over the last year. Estimated average prices increased from \$8.21 in 2017 to \$11.93 per pound in 2018. A majority of the 2018 primary molybdenum production in the U.S. was from two Colorado mines that produced approximately 35 million pounds combined. In the U.S., Colorado ranked second in molybdenum production following molybdenum recovered as a byproduct of copper mining at several Arizona mines (**Figure 21**).

In Colorado, molybdenum is mined at the Climax and Henderson mines by Freeport-McMoRan Inc. (Freeport). As reported by Freeport, the Climax Mine is located northeast of Leadville, at Fremont Pass, and includes a 27,600 ton per day mill with the ability to produce about 30 million pounds of molybdenum per year. The mine reopened in mid-2012 after being shut down for 17 years. Freeport reported that the Climax open pit mine produced 23 million pounds of molybdenum in 2015, 16 million pounds in 2016, 20 million pounds in 2017, and 21 million pounds in 2018. In 2018, Freeport also reported that the Climax Mine had 158 million metric tons of proven reserves at a grade of 0.15% molybdenum.

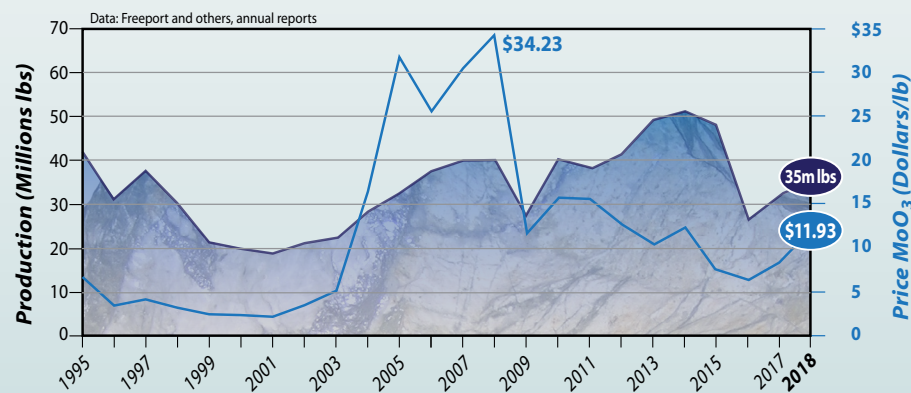


Figure 20. Molybdenum production in Colorado and average annual price, 1995–2018.

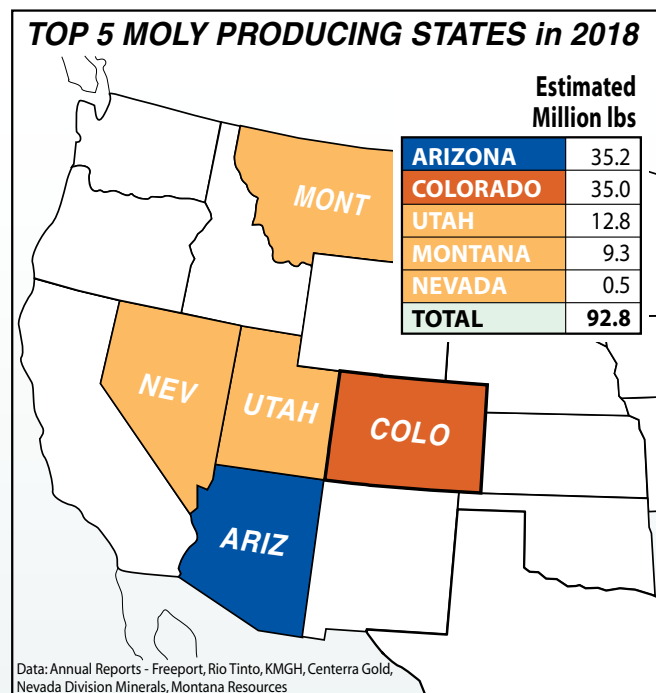


Figure 21. Top five molybdenum producing states, 2018.

The Henderson Mine, located near Empire in Clear Creek County, has been in operation since 1976. According to Freeport, this operation is a large block-cave underground mine connected to a 35,300 tons per day concentrator in adjoining Grand County by a 15-mile 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, and 14 million pounds in 2018. In 2018, Freeport also reported that the Henderson Mine had 58 million metric tons of proven reserves at a grade of 0.18% molybdenum.

Gold and Silver

According to the USGS, U.S. gold production decreased from 261 tons (7.6 million troy ounces) in 2017 to an estimated 231 tons (6.7 million troy ounces) in 2018 with an estimated value of \$8.6 billion. In 2018, the U.S. was the fourth largest producer of gold in the world following China (441 tons), Australia (342 tons), and Russia (325 tons). **Figure 22** shows the price of gold and Colorado gold production from 1990 to 2018. In 2018, Colorado was the third top producer of gold (360,000 ounces) in the U.S. (**Figure 23**) following Nevada (about 5,581,160 ounces) and Alaska (about 502,998 ounces). The average gold price in 2018 was \$1,270 per ounce.

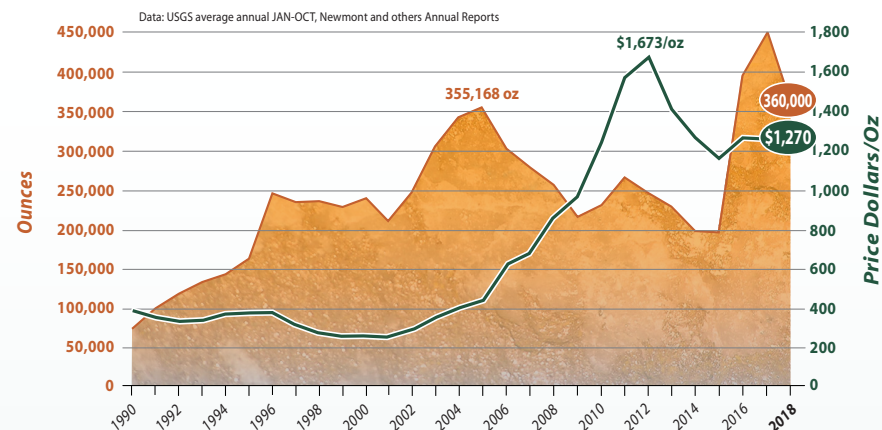


Figure 22. Colorado estimated gold production and average annual price per ounce, 1990–2018.

Production of gold at Newmont's Cripple Creek and Victor (CC&V) open pit mine located in Teller County decreased from 451,000 ounces in 2017 to 360,000 ounces in 2018 likely due to lower-grade ore mined at CC&V and other factors according to Forbes. Estimated average gold prices increased from \$1,261 in 2017 to \$1,270 per ounce in 2018. Silver is also produced from CC&V; however, silver production is not reported from this mine. In 2019, Newmont acquired Goldcorp Inc. and entered into a joint venture with Barrick Gold in Nevada making it the



Cresson pit operations near Victor. Photo Credit: hopkins/neoscenes ©2019

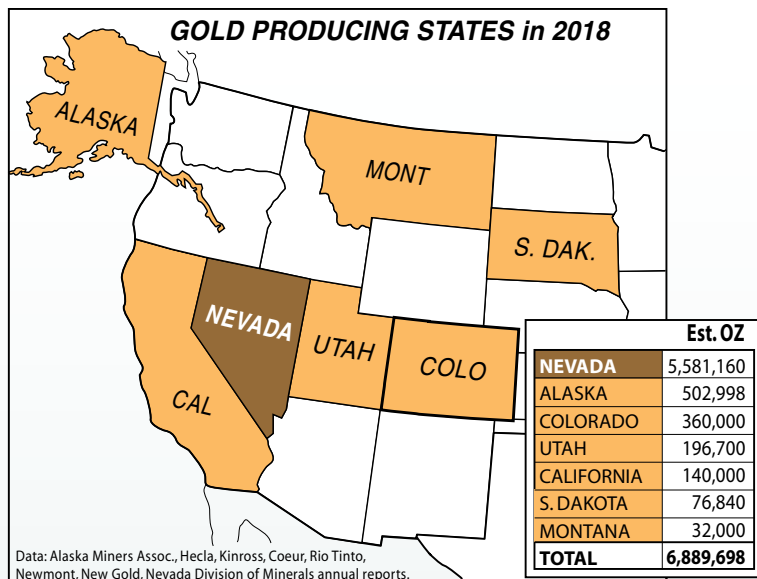


Figure 23. Major gold-producing states in 2018.

largest gold mining company in the world now known as Newmont Goldcorp. Their corporate headquarters remains in Greenwood Village, Colorado. Newmont was the second largest producer of gold in the world in 2017 and 2018.

A smaller amount of placer gold is recovered from sand and gravel aggregate operations 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 likely produce, but do not report, small tonnages of high-grade gold and silver ore. There are currently 32 active mining permits with gold listed as the primary mined commodity in the Colorado Division of Reclamation, Mining and Safety (DRMS) database.

In 2018, Aurcana Corporation (Aurcana) purchased Ouray Silver Mines Inc. (OSM) and continued to develop the Revenue-Virginus Mine for potential start-up. The mine will produce primarily silver, mostly associated with quartz veins in volcanic rock, while recovering other metals such as gold, lead, and zinc as by-products. Located in Ouray County near the town of Ouray, the Revenue-Virginus was one of the largest and most historic mines in the county. The mine opened in 1876, with underground production beginning in 1880, and by 1921 had produced gold and silver ore worth more than \$28 million. A 2018 feasibility study for three vein systems at the mine reported proven and probable mineral reserves containing approximately 14.2 million ounces of silver with an average grade of 24.7 silver ounces per short ton.



The Hidee Mine operating as a tourist gold mine near Central City. Vince Matthews photo.

Other Exploration Activities and Mining Information

S&P Global Market Intelligence provides an annual report on world exploration trends focused on gold, silver, base metals, platinum group metals, diamonds, uranium, rare earths, and potash. The 2018 report indicated that worldwide exploration budget estimates for nonferrous metals were up 18% from the 2017 total. Their 2018 estimated global exploration budget for nonferrous metals was \$10.1 billion. Most of this estimated total budget is for exploration targeting gold (50%), copper (22%), and lead/zinc (7%). As they did in 2017, worldwide estimated exploration budgets for lithium and cobalt increased in 2018.

Exploration and development projects that have undergone at least some recent activity are discussed below. Most of this information is compiled from company websites and available reports. Past CGS MEIA reports have additional information about these projects and updates associated with other properties including the Golden Wonder Mine, San Juan Silver Project, Silver Cliff Property, Tomichi Copper-Molybdenum Project, and Klondike Mine.

GS Mining Company (GS Mining) recently announced that their subsidiary, BH Mining Company, LLC, completed exploration drilling activities in 2018 and continues to dewater and rehabilitate the ***Bates Hunter Mine***, primarily a gold mine, located in the Central City mining district in Gilpin County. GS Mining also reported that their other subsidiary, the Clay Mine Acquisition Company, LLC, has executed an option to acquire the nearby Clay County Mine. The Central City Mining District is historically known for its gold production but

also produced silver with minor amounts of lead, zinc, and copper. Generally, the mineralization occurs in veins and stockworks genetically related to early-Tertiary age igneous rocks, dikes and irregular plutons intruded into Precambrian rocks.

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 Canon City in Fremont County. The Dawson Project, located on the eastern end of the property, includes gold mineralized areas within a Precambrian-age granite and associated rocks. In 2018, Zephyr completed additional geological mapping, drilling, sampling, and a geophysical survey at the Dawson Property and also 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.

Dateline Resources (Dateline) acquired the **Gold Links Mine** in 2016 and is currently performing exploration activities on the property. Dateline also acquired the nearby Raymond and Carter mines. They also own the Lucky Strike Mill where, according to their website, they have completed updates to the mill and plan on testing material from the Gold Links Mine. These mines are located in the Gold Brick mining district in eastern Gunnison County. The 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 metavolcanic and granitic rocks.

Late in 2019, Metallic Minerals Corp. (Metallic Minerals) announced that it entered into an agreement to perform exploration activities on their **La Plata Property** located 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. The igneous rocks in this area were intruded during the Late Cretaceous-early Tertiary into older sedimentary rocks. According to the USGS, Spanish explorers 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.

Critical Minerals

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 (SI) in coordination with other federal agencies, was defined as a non-fuel mineral or mineral material essential to the economic and national security of the U.S., the supply chain of which is vulnerable to disruption and, that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security.

E.O. 13817 also requires that within 180 days of publishing a list of critical minerals, a report will be submitted that will provide:

- 1.) a strategy to reduce U.S. reliance on critical minerals,
- 2.) plans to improve the mapping of the U.S. and providing accessible electronic data,
- 3.) a progress assessment toward developing critical mineral recycling, reprocessing, and alternative technologies and,
- 4.) options for developing critical minerals through investment and trade with U.S. allies and partners.

The USGS, in coordination with the Bureau of Land Management (BLM), provided the draft critical mineral list, through U.S. Department of the Interior (DOI) Secretarial Order No. 3359 (Subject: Critical Mineral Independence and Security) as documented in the USGS Open-File Report 2018-1021. The USGS notes in this document that the “categorization of minerals as critical may change during the course of the review process and is thus provisional.” 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.

Minerals containing almost all the elements provided in the critical mineral list occur in Colorado. However, many of these may not occur in sufficient quantities to mine economically. Colorado is a known producer or past producer of many of the minerals/mineral materials provided in the critical minerals list especially (in no particular order) helium, tungsten, uranium, 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.

Lithium

As reported by the USGS, lithium is used in batteries, ceramics, glass, lubricating greases, and other applications. Rechargeable lithium-ion batteries are typically used in portable electronics, energy storage systems, automobiles, and other consumer electronic products. These batteries enhance the efficiency of renewable energy sources (e.g. wind and solar) by storing energy during times of lower demand. The demand for lithium has risen due to the increased use of batteries especially associated with electric and hybrid vehicles, electric tools, portable electronics (e.g. smart phones, tablets, laptops, etc.), and potentially, energy storage grids. In 2018, the main producers of lithium included Australia, Chile, China, and Argentina. Lithium production data from the U.S. is withheld for proprietary reasons. According to the USGS, the only production of lithium in the U.S. in 2017 and 2018 was from a brine operation in Nevada (Silver Peak lithium mine).

Lithium is mainly associated with pegmatites (coarse grained granites) and naturally occurring brines that contain high concentrations of dissolved salts. Although current lithium production is dominated by pegmatite mining in Australia, the production of lithium carbonate from brines in South America is produced at a lower cost. Brines occur in the Paradox Basin which straddles the Colorado-Utah border in southwestern Colorado. The Paradox Basin brines in Colorado might host economic deposits of lithium, bromine, and potassium associated with evaporates in the Paradox Formation located within the basin. In 2017, at least one company, New Tech Minerals Corp. (New Tech) (previously New Tech Lithium Corp.) acquired federal lithium and bromine placer mining claims in San Miguel County in two areas, southeast Lisbon Valley and Andys Mesa, overlying the southeast extension of the Paradox Formation evaporate beds. As reported last year, lithium-bearing brines have been documented in historic oil and gas wells. In 2018, MGX Minerals (MGX) reports that they have developed a lithium extraction process that could potentially be used to recover lithium from oil and gas wastewater (otherwise known as petrolithium). MGX reports that it is concurrently exploring for oil, gas, lithium and other brine-related minerals to determine where to test their extraction process. They report that their current potential resource estimates, mainly for oil and gas, include leasehold and royalty interests in Utah and San Miguel County, Colorado

Vanadium

Vanadium in Colorado is generally associated with the sandstone-hosted uranium deposits located in western Colorado, specifically on the Colorado Plateau in the Uravan area. As one author notes,

“Historically, the most important vanadium deposits are located in the Uravan Mineral Belt on the Colorado-Utah border, the Placerville deposits in San Miguel County and the Rifle Creek deposits in Garfield County, both in Colorado (Hammond, 2013).”

There are currently no mines in production and the last vanadium production reported in Colorado was in 2005. Small amounts of vanadium were reportedly produced in 2011 as a byproduct in one uranium mine in Utah. As reported last year, several companies are exploring or maintaining uranium-vanadium properties in western Colorado. These companies include Anfield Energy Inc., Energy Fuels Inc., Pedro Resources, Ltd., United Battery Metals Corp., and Western Uranium Corporation. More information can be found on their websites.

In 2017 and 2018, China, Russia, and South Africa were the top three producers of vanadium. If Colorado uranium mining resumes in the future, vanadium would likely be produced as a by-product. Average vanadium prices are on the rise. As reported by the USGS, vanadium pentoxide prices increased from \$3.38 in 2016 to \$7.61 in 2017, and to \$14.00 per pound in 2018. In 2017 and 2018, vanadium was mainly used in the production of steel alloys. Vanadium can also be used in vanadium redox battery (VRB) technology. VRBs are large scale batteries that are nonflammable, reusable, long lasting, and scalable making them desirable for use in industrial and utility scale applications. According to Hammond (2013), vanadium-lithium phosphate batteries are currently used in some portable electronic devices, contain 20% more storage power than lithium-cobalt batteries, and could extend the driving ranges of electric vehicles

SEC Property Disclosures

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. 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 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. More information and a link to the final rules are located on the SEC website:

<https://www.sec.gov/news/press-release/2018-248>

Proposed Federal Mining Law Reform

In 2019, two proposed mining bills were introduced to federal legislators including the Hardrock Mining and Reclamation Act of 2019 (S. 1386), originally introduced in 2015, and the Hardrock Leasing and Reclamation Act of 2019 (H.R. 2579). The current Mining Law of 1872 governs the acquisition of federal public lands for minerals by the “location and maintenance” of mining claims (BLM, 2019). Locatable minerals include metallic-bearing minerals as well as some non-metallic minerals. Both of these bills attempt to modify current requirements associated with locatable minerals on federal public lands. The proposed S. 1386 imposes a royalty on hardrock mining, establishes a Hardrock Minerals Reclamation Fund to assist with abandoned mine cleanup, requires federal exploration and mining operation permits for “non-casual” mining operations, and reportedly “encourages local autonomy over mining and gives states, political subdivisions, and Indian tribes the authority to petition the Secretary of the Interior to withdraw certain lands from mining (Udall, 2019).” H.R. 2579 would reportedly establish a royalty on hardrock mining, require “meaningful tribal consultation”, allow management through existing land-use planning, establish “special lands” that cannot be mined, create new reclamation and bonding rules, and create a fund to assist with abandoned mine cleanup (NRC, 2019). For more information about these bills, including the original text and status, see www.congress.gov.

AGGREGATE – SAND, GRAVEL, AND CRUSHED STONE

The primary uses of sand and gravel as reported by the USGS for 2018 are concrete aggregates, road base and coverings, road stabilization, construction fill, asphaltic concrete and other bituminous mixtures, and other concrete products. Other uses include plaster and gunite sands, snow and ice control, filtration, railroad ballast, and roofing granules. Crushed stone is primarily used for construction material especially in road construction/maintenance and cement manufacturing. DRMS lists over 650 active permits for sand, gravel, aggregate, and aggregate-related quarries in Colorado.

The USGS estimates that Colorado quarry operators produced 51.81 million tons of aggregate (sand, gravel, and crushed stone) in 2018 (**Figure 24**). The estimated 2018 production value was \$284 million for sand and gravel and \$141 million for crushed stone. Average prices and production for sand and gravel and crushed stone are shown in **Figure 25** and **Figure 26**, respectively.

Colorado uses a large amount of aggregate to build and maintain infrastructure. The cost of aggregate to the user is highly dependent on aggregate transportation costs. Locating quarries close to population centers helps lower overall costs. 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, CGS created Special Publication 5A and 5B, Sand Gravel and Quarry Aggregate Resources, Colorado Front Range Counties (Schwochow and others, 1974). Digital versions of the aggregate resource maps can be found in CGS OF-00-09 Atlas of Sand, Gravel, & Quarry Aggregate Resources, Colorado Front Range

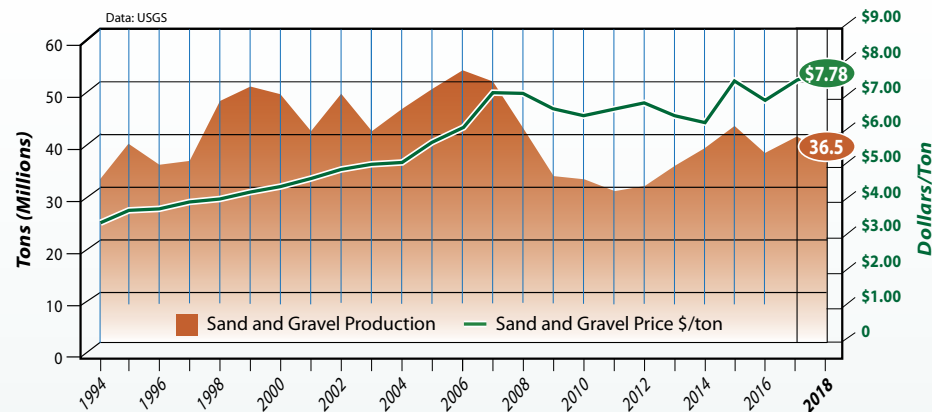


Figure 25. Price and production of sand and gravel aggregate in Colorado, 1994–2018.

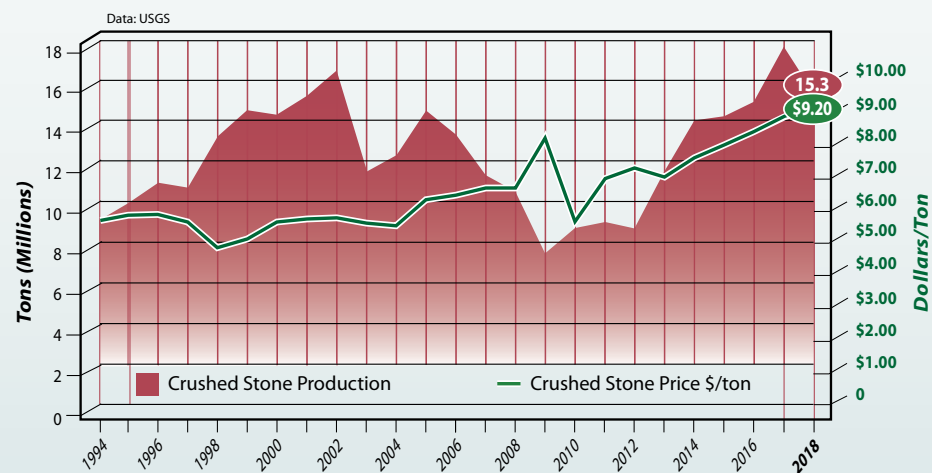


Figure 26. Price and production of crushed stone aggregate in Colorado, 1994–2018.

(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>

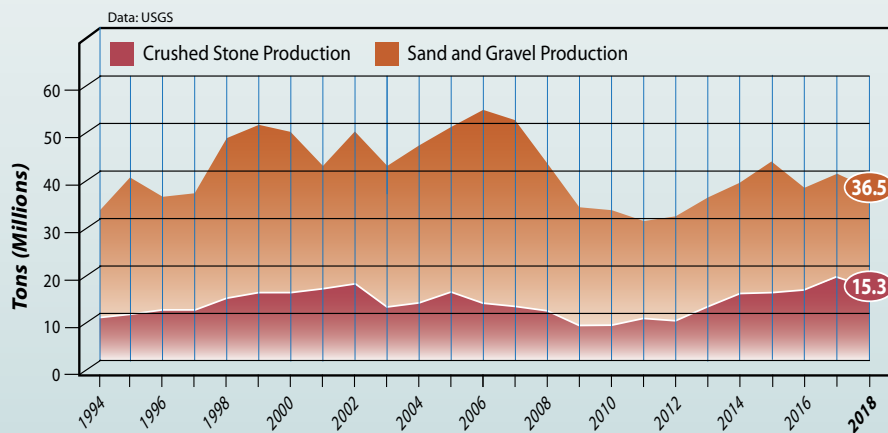


Figure 24. Aggregate production in Colorado, 1994–2018.

For additional information, please see the following website:

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

Cement

Portland cement in Colorado is used primarily in the production of concrete. Concrete consists of a mixture of aggregates and paste. Sand, gravel, or crushed stone is mixed with water and cement. According to the Portland Cement Association, cement is created by heating lime, silica, alumina, iron, and other materials at high temperatures which creates small round pellets called clinkers that are ground, mixed with limestone and gypsum, and used to make concrete. As in 2017, three Portland cement plants operated in Colorado during 2018: LafargeHolcim (US), Inc. (Holcim) 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. The USGS estimated Portland cement production (e.g. shipments from Colorado) in 2018 was 2.5 million tons. Production and average cement prices are shown on **Figure 27**.

Clay and Shale

Clay is mined primarily in eastern Colorado along the Front Range and is used mostly to make brick and tile. Clay has been mined from the Laramie Formation, Dawson Arkose, and Denver Formation as well as the Dakota Group. DRMS records indicate that there are 30 active permits for clay in Colorado. 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. The Acme Brick Co. brick plant in Castle Rock, Douglas County, shut down in 2018. Preliminary common clay and shale production was estimated at 251,000 tons in 2015 and 222,000 tons in 2016. The USGS estimated average price of common clay and shale was approximately \$11.79 per ton in 2018. Published production estimates for clay and shale were unavailable in 2017 and 2018.

Gypsum

Gypsum mined in Colorado is used for the production of 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. 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. Gypsum is also mined in Larimer and Fremont counties. Pete Lien & Sons mines gypsum for the cement industry and soil amendment from the Munroe Quarry north of Fort Collins in Larimer County. As reported by the USGS, crude gypsum production in the U.S. increased about 1.4% in 2018 and was estimated at 23.1 million tons. Production information on Colorado gypsum 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 industrial 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 (NaHCO_3). High grade nahcolite (greater than 80%) is recovered from the Boise Bed in the Green River Formation of the Piceance Basin. Hot water is pumped down a well approximately 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 is allowed to cool and precipitate sodium bicarbonate which is further dried and prepared to produce commercial grade product. Natural Soda completed an expansion project in 2013 to double the mine's production capacity to 250,000 tons per year. Production in 2017 and 2018 was 236,000 and 188,000 tons, respectively (**Figure 28**). Natural Soda indicated that 2019 production will be back in the 235,000 ton range.

Silica

Sand is mined in Colorado for use as a silica additive in cement manufacturing. Well-rounded quartz sand from eolian deposits has been mined for filtration and water well packing purposes. Depending on the application and other

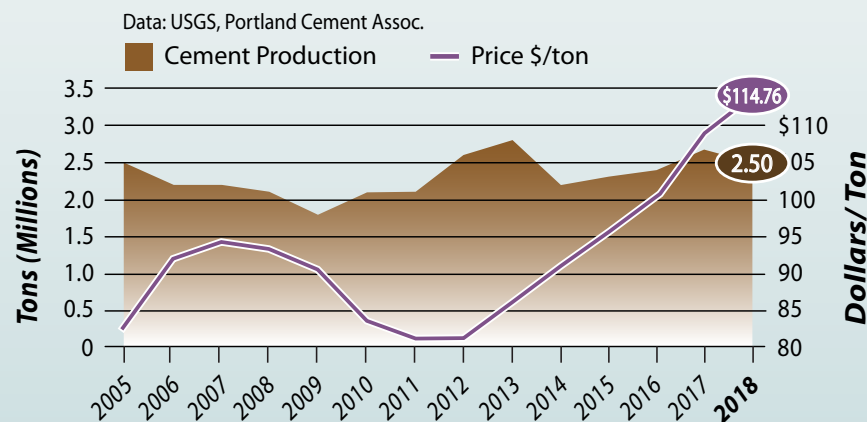


Figure 27. Price and production of cement in Colorado, 2005–2018.

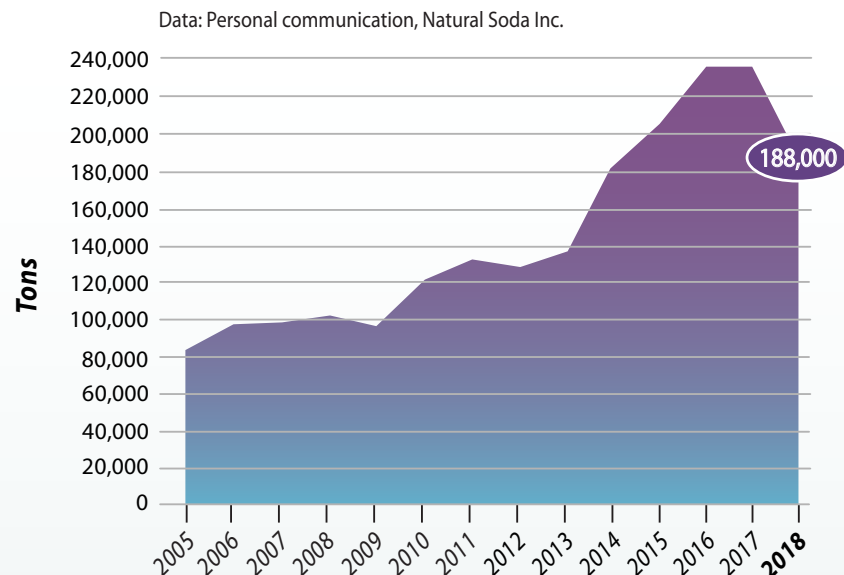


Figure 28. Estimated production of nahcolite in Colorado, 2005–2018.

factors, silica prices are highly variable. In 2017, the average national price for industrial silica sand and gravel reported by the USGS was \$53.10 per metric ton. As reported by the USGS, the production value of industrial sand and gravel in 2018 increased by 22% over the last year and by 130% when compared to 2016 production values. This increase has been mainly due to an increase in demand for hydraulic fracturing sand (also called “frac” or “proppant” sand). These sands are used in the hydraulic fracturing process to prop open rock fractures and facilitate the flow of oil and gas to wells. In 2017, about 73% of industrial sand and gravel sold or used by U.S producers was used for hydraulic fracturing and well packing and cementing. Production information of industrial sand in Colorado was withheld by the USGS to avoid disclosing proprietary data. The CGS published a reconnaissance study of potential sources of sand for hydraulic fracturing available here:

<https://store.coloradogeologicalsurvey.org/product/potential-sand-sources-hydraulic-fracturing/>.

Limestone, Calcium Carbonate, and Lime

Limestone is mined in Colorado for aggregate, dimension stone, and quicklime for cement production. Lime is made by calcining (e.g. burning) high-purity limestone to form calcium oxide, commonly called quicklime. Other uses include soil conditioner, water and sewage treatment, and food products. Limestone

occurs in many locations in the state and has been quarried in Boulder, El Paso, Fremont, Garfield, Larimer, and Moffat counties for cement, concrete, and/or other limestone products. Limestone is ground into a calcium carbonate powder at some facilities and is used for a variety of purposes including a filler for roofing shingles, fire suppression in underground coal mines, calcium supplement for liquid animal feed, and other uses. According to data provided by the USGS, quicklime sold for an average of about \$120 per ton nationally in 2018.

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, walk ways (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 2017 based on USGS data. According to USGS estimates, Colorado produced about 32,388 tons of dimension stone in 2017 with an estimated production value of \$11.9 million. Colorado data for 2018 were unavailable at the time of this report. In 2017, Colorado was a minor producer while Texas, Indiana, Wisconsin, Massachusetts, and Georgia accounted for about 69% of U.S. production. The majority of rock types sold in the U.S. in 2018 by descending value included limestone, sandstone, granite, miscellaneous stone, marble, and slate.

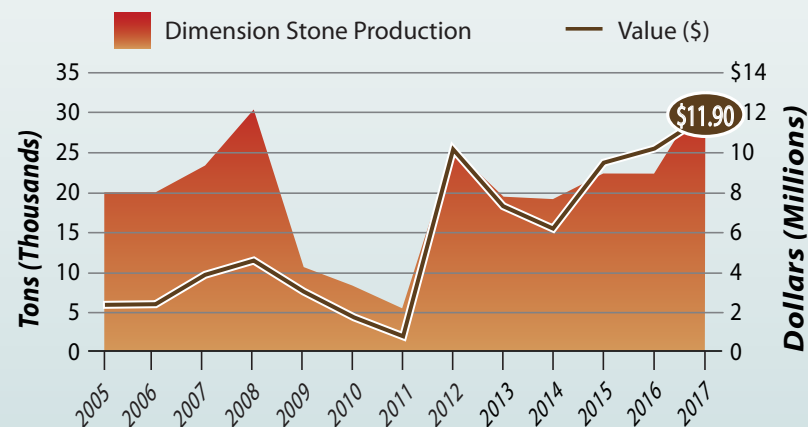


Figure 29. Production and product value of dimension stone in Colorado, 2005–2017.

INDUSTRIAL GASES (NON ENERGY)

Carbon Dioxide

Naturally occurring carbon dioxide gas (CO₂) was produced in 2018 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. 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 Doe Canyon Deep units are the largest producers in Colorado. CO₂ is produced from wells in a similar way to natural gas production. The CO₂ is mostly used in enhanced oil recovery (EOR) in Texas and New Mexico. EOR is the implementation of various techniques for increasing the amount of crude oil that can be extracted 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 2018, Colorado produced an estimated 419 billion cubic feet (Bcf) at an estimated average price of \$1.02 per thousand cubic feet (Mcf) for an estimated value of \$428 million. **Figure 30** shows Colorado's estimated CO₂ production for the period 1994-2018. CO₂ production from Montezuma County, McElmo Dome, accounted for about 90% of the total Colorado production.

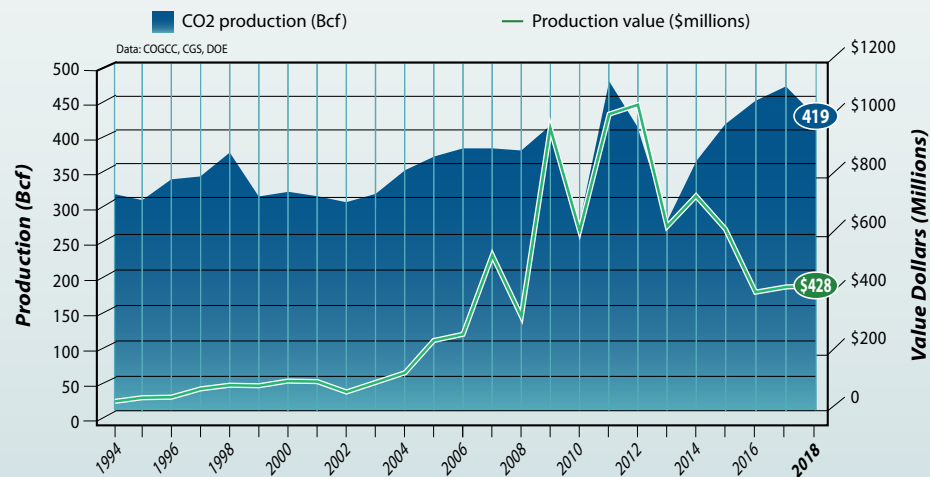


Figure 30. CO₂ production and estimated production value in Colorado, 1994–2018.

Helium

In 2017, 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. Grade-A helium is produced by DCP Midstream LLC at the Ladder Creek gas plant facility located in Cheyenne Wells, Cheyenne County in southeastern Colorado. In 2015, Air Products and Chemicals, Inc. (Air Products) built a helium production facility in Doe Canyon. Most of the helium is extracted from a gas stream composed primarily of carbon dioxide. The plant has a capacity of about 230 million standard cubic feet per year. IACX Energy, a midstream company, reportedly has an operating helium recovery unit in the Badger Wash area in Mesa County. The price for private industry grade-A helium as reported by the USGS in 2018 was about \$210 per Mcf.

Although the U.S. appears to have abundant reserves, helium was listed as a critical mineral by the USGS in 2018. In 2018, the USGS reported that 42% of U.S. helium production was provided by the federal helium storage facility at Cliffside Field in Texas. However, the Bureau of Land Management (BLM), who manages the federal helium program under the Helium Stewardship Act of 2013, will terminate this program no later than 2021 or when the remaining helium stockpile falls below a predetermined threshold. As reported by the USGS, “By the end of the decade, international helium extraction facilities are likely to become the main source of supply for world helium users” (USGS, 2019).

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References

- Aurcana Corporation <http://www.aurcana.com/operations/ouray-silver-mine/>
- Barrick Gold Annual Report <https://www.barrick.com/>
- Birdwell, J.E., Mercier, T.J., Johnson, R.C., and Brownfield, M.E., 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 2012-3145, 4 p. <https://pubs.usgs.gov/fs/2012/3145/>
- Bureau of Land Management (BLM), 2019, About Mining and Minerals, website visited 10/19. <https://www.blm.gov/programs/energy-and-minerals/mining-and-minerals/about>
- Canon City Daily Record <https://www.canoncitydailyrecord.com/2018/05/12/zephyr-minerals-begins-drilling-with-dawson-gold-project/>
- Cappa, J.A., O’Keeffe, M.K., Guilinger, J.R., and Berry, K.A., 2017, Colorado Mineral and Energy Industry Activities 2015-2016, Colorado Geological Survey, Information Series 79, 35 p., <https://store.coloradogeologicalsurvey.org/product/mineral-energy-industry-activities-colorado-2015-2016/>
- Cappa, J.A., Sadlick, J., Litke, D.W., McCormick, M.L., and Hiatt, C.S., 2000, A digital representation of the 1974 atlas by 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, Colorado Geological Survey Open File (OF) 00-09. <https://store.coloradogeologicalsurvey.org/product/atlas-sand-gravel-quarry-aggregate-resources-colorado-front-range/>
- Colorado Department of Local Affairs <https://www.colorado.gov/pacific/dola/direct-distribution-severance-tax-federal-mineral-lease>
- Colorado Department of Public Health and Environment, (CDPHE) Air Pollution Control Division https://www.colorado.gov/pacific/sites/default/files/AP_PO_Regional-Haze-State-Implementation-Plan-Dec-2016.pdf
- Colorado Department of Revenue <https://www.colorado.gov/pacific/revenue/annual-report>
- Colorado Division of Reclamation, Mining and Safety <http://mining.state.co.us/Reports/Reports/Pages/Coal.aspx>
- Colorado Division of Reclamation, Mining and Safety <http://mining.state.co.us/Reports/MiningData/Pages/default.aspx>
- Colorado Division of Reclamation, Mining and Safety <http://mining.state.co.us/Reports/Pages/GISData.aspx>
- Colorado General Assembly <https://leg.colorado.gov/agencies/office-legislative-legal-services/colorado-revised-statutes>
- Colorado Geological Survey, historic mining districts website <http://coloradogeologicalsurvey.org/mineral-resources/historic-mining-districts/>

Colorado Oil and Gas Conservation Commission	https://cogcc.state.co.us/data4.html#/production
Colorado Oil and Gas Conservation Commission	https://cogcc.state.co.us/data.html#/cogis
Colorado Oil and Gas Conservation Commission	https://cogcc.state.co.us/data2.html#/downloads
Colorado Oil and Gas Conservation Commission	https://cogcc.state.co.us/sb19181.html#/overview
Colorado Oil and Gas Conservation Commission, 2018, 2018 Annual Report to the Water Quality Control Commission and Water Quality Control Division of CDPHE, dated 30 December 2018, 53 p.	https://cogcc.state.co.us/library.html#/technicalreports
Colorado Public Radio	https://www.cpr.org/2019/11/08/federal-judge-blocks-the-west-elk-coal-mine-expansion-after-environmental-groups-sue/
Colorado State Land Board	https://www.colorado.gov/pacific/statelandboard/reports-2
Couder Mining	https://www.coeur.com/
Craig Daily Press	https://www.craigdailypress.com/news/colowyo-coal-company-prepares-to-dig-into-collom-expansion-south-of-craig/
Cunningham, C.G., Naeser, C.W., Marvin, R.F., Luedke, R.G., and Wallace, A.R., 1994, Ages of Selected Intrusive Rocks and Associated Ore Deposits in the Colorado Mineral Belt, U.S. Geological Survey Bulletin 2109, 31 p.	https://pubs.usgs.gov/bul/2109/report.pdf
Dateline Resources	https://www.datelineresources.com.au/
Denver Post	https://www.denverpost.com/2019/09/21/tri-state-closes-nucula-coal-plant/
Durango Herald	https://durangoherald.com/articles/295022
Eckel, E.B., Williams, J.S., and Galbraith, F.W., 1949, Geology and Ore Deposits of the La Plata District, U.S. Geological Survey Professional Paper 219, 179 p.	https://pubs.usgs.gov/pp/0219/report.pdf
Equinox Gold	https://www.equinoxgold.com/
Forbes, 2019	https://www.forbes.com/sites/greatspeculations/2019/02/20/newmont-minings-results-likely-to-see-lower-production-and-declining-prices-outlook-remains-bright/#c1668133aee0
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-McMoran 10K	https://www.fcx.com/
Globe News Wire	https://globenewswire.com/news-release/2019/09/10/1913434/0/en/Metallic-Minerals-Acquires-La-Plata-Silver-Gold-Copper-Property-in-Southwest-Colorado-and-Initiates-Property-Wide-Exploration-Program.html
GS Mining Company, LLC	https://gsminingcompany.com/projects/bates-hunter-mine-2019
Hammond, A.D., 2013, Vanadium, the new green metal: Mineral deposits in the Colorado Plateau, Mining Engineering, December, 8 p.	http://me.smenet.org/
Hecla Mining Company	https://www.hecla-mining.com/

Kinder Morgan	https://www.kindermorgan.com/
Kinross Annual Report	https://www.kinross.com/
Lovering, T.S. and Goddard, E.N., 1950, Geology and Ore Deposits of the Front Range Colorado, U.S. Geological Survey Professional Paper 223, 319 p.	https://pubs.er.usgs.gov/publication/pp223
MGX Minerals	https://www.mgxminerals.com/
MGX Minerals	https://www.mgxminerals.com/investors/news/2018/355-mgx-minerals-expands-utah-petrolithium-project-acquires-additional-oil-and-gas-leases-at-paradox-basin.html
Metallic Minerals Corp.	https://www.metallic-minerals.com/
Montana Resources	https://www.montanaresources.com/
Natural Soda	https://www.naturalsoda.com/
Nevada Division of Minerals	http://minerals.nv.gov/Programs/Mining/Mining/
Newmont Goldcorp 10K	https://www.newmontgoldcorp.com/
Newswire	https://www.newswire.ca/news-releases/zephyr-discovers-magnetic-anomaly-at-el-plomo-section-of-dawson-green-mountain-property-855325029.html
NRC (National Resources Committee), 2019, Mining Reform Legislation, Fact Sheet, 1 p.	https://naturalresources.house.gov/imo/media/doc/HR%202579%20Mining%20Reform%20Fact%20Sheet.pdf
O’Keeffe, M.K., 2018, Colorado Aggregate Resources - Geology and Industry Overview, an ArcGIS Story Map, Colorado Geological Survey online map.	https://cologeosurvey.maps.arcgis.com/apps/MapSeries/index.html?appid=e2f8ad18c3384707a65cc4b03f15280c
O’Keeffe, M.K. and Morgan, M.L., 2018, Colorado Front Range Sand, Gravel, and Quarry Aggregate Resources, Digital ArcGIS File 2018 Update and Online Map Project, originally published in 2000 as CGS Open-File Report OF-00-09 and in 1974 as CGS Special Publication 5-A and 5-B, Colorado Geological Survey.	https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html?id=003cf86ff0e6440989b1496e368c115e/
O’Keeffe, M.K., Peretyatko, A.I., and Berry, K.A., 2018, Colorado Mineral and Energy Industry Activities 2017-2018, Colorado Geological Survey Information Series 81, 29 p.	https://store.coloradogeologicalsurvey.org/product/colorado-mineral-energy-industry-activities-2018/
Ouray Silver Mines	https://ouraysilvermines.com/
Portland Cement Association	https://www.cement.org/
Rio Tinto Annual Report	https://www.riotinto.com/ t
S&P Global Market Intelligence	https://www.spglobal.com/marketintelligence/en/news-insights/trending/bByVH9BMo2_AWhOf_IVQDQ2
S&P Global Market Intelligence	https://www.spglobal.com/marketintelligence/en/news-insights/research/world-exploration-trends-2018
Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., 2017, Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, 797 p.	https://pubs.er.usgs.gov/publication/pp1802
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 Publication 5-B, 47 p.

Silbaugh, L., 2018, Effective Severance Tax Rates on Oil and Gas, Colorado Legislative Council Staff Memorandum, 12 January 2018, 13 p.

Streufert, R.K., 1999, Geology and Mineral Resources of Gunnison County, Colorado, Colorado Geological Survey Resource Series 37, 76 p.

The Journal

Udall, Tom, 2019, Hardrock Mining Reform Act of 2019 Fact Sheet, 1 p.

U.S. Congress

U.S. Department of Energy

U.S. Department of Energy, Office of Legacy Management

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Energy Information Administration

U.S. Federal Energy Regulatory Commission

U.S. Federal Register

U.S. Federal Register

U.S. Federal Register

U.S. Geological Survey (USGS), 2019

U.S. Geological Survey

U.S. Geological Survey

<https://store.coloradogeologicalsurvey.org/>

<https://leg.colorado.gov/publications/effective-severance-tax-rates-oil-and-gas>

<https://store.coloradogeologicalsurvey.org/product/geology-mineral-resources-gunnison-colorado/>

<https://the-journal.com/articles/137508>

[https://www.tomudall.senate.gov/imo/media/doc/Hardrock %20Mining%20Reform%20Act%202019,%20one-pager.pdf](https://www.tomudall.senate.gov/imo/media/doc/Hardrock%20Mining%20Reform%20Act%202019,%20one-pager.pdf)

www.congress.gov

<https://www.energy.gov/sites/prod/files/VRB.pdf>

<https://www.energy.gov/lm/articles/renewed-uranium-leases-come-stricter-environmental-standards>

<https://www.eia.gov/naturalgas/crudeoilreserves/>

<https://www.eia.gov/state/?sid=CO>

<https://www.eia.gov/tools/faq47&s/faq.php?id=8t=6>

<https://www.eia.gov/tools/faqs/faq.php?id=207&t=21>

<https://www.eia.gov/outlooks/aeo/>

https://www.eia.gov/dnav/pet/pet_pri_dfp1_k_a.htm

<https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm>

https://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm

<https://www.eia.gov/coal/annual/>

<https://www.eia.gov/uranium/production/annual/>

<https://www.eia.gov/uranium/production/quarterly/>

<https://www.eia.gov/todayinenergy/detail.php?id=39352>

<https://www.eia.gov/todayinenergy/detail.php?id=40134>

<https://www.ferc.gov/industries/gas/enviro/eis/2019/03-29-19-DEIS.asp>

<https://www.federalregister.gov/documents/2017/12/26/2017-27899/a-federal-strategy-to-ensure-secure-and-reliable-supplies-of-critical-minerals>

<https://www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018>

<https://www.federalregister.gov/documents/2018/02/16/2018-03219/draft-list-of-critical-minerals>

<https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/mcs-2019-heliu.pdf>

<https://minerals.usgs.gov/minerals/pubs/commodity/> (see aggregate, sand and gravel, gypsum, clay, etc.)

<https://minerals.usgs.gov/minerals/pubs/mcs/>

U.S. Geological Survey	https://minerals.usgs.gov/minerals/pubs/commodity/molybdenum
U.S. Geological Survey	https://minerals.usgs.gov/minerals/pubs/commodity/lithium
U.S. Geological Survey	https://www.usgs.gov/centers/nmic/gold-statistics-and-information
U.S. Securities and Exchange Commission	https://www.sec.gov/news/press-release/2018-248
Uranium Miner	http://www.uraniumminer.net/
White House	https://www.whitehouse.gov/presidential-actions/memorandum-effect-uranium-imports-national-security-stablishment-united-states-nuclear-fuel-working-group/
White House	https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-secure-reliable-supplies-critical-minerals/
Zephyr Minerals Ltd.	https://www.zephyrminerals.com/