

INFORMATION SERIES 81

# Colorado Mineral and Energy Industry Activities 2017-2018

by Michael K. O'Keefe, Alexander I. Peretyatko, and Karen A. Berry





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Cover:

Storage tanks on Weld County 49 corridor by Larry Scott, CGS.

*(Design/layout and other photos in report by Larry Scott unless otherwise noted)*

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# EXECUTIVE SUMMARY

In 2017, Colorado produced several mineral and energy commodities. Top commodities, in terms of production value, include oil, natural gas, coal, gold, industrial gases (carbon dioxide and helium), sand and gravel, cement, molybdenum, and crushed stone. The total value of mineral and energy fuels production in Colorado for 2017 is estimated to be \$14.13 billion. The mineral production value for 2017 is separated into commodity types in **Figure ES-1**. Oil and natural gas production accounted for approximately 80% of Colorado's total mineral and energy production value in 2017. Estimated mineral and energy production values for 1994 through 2017 are shown in **Figure ES-2**.

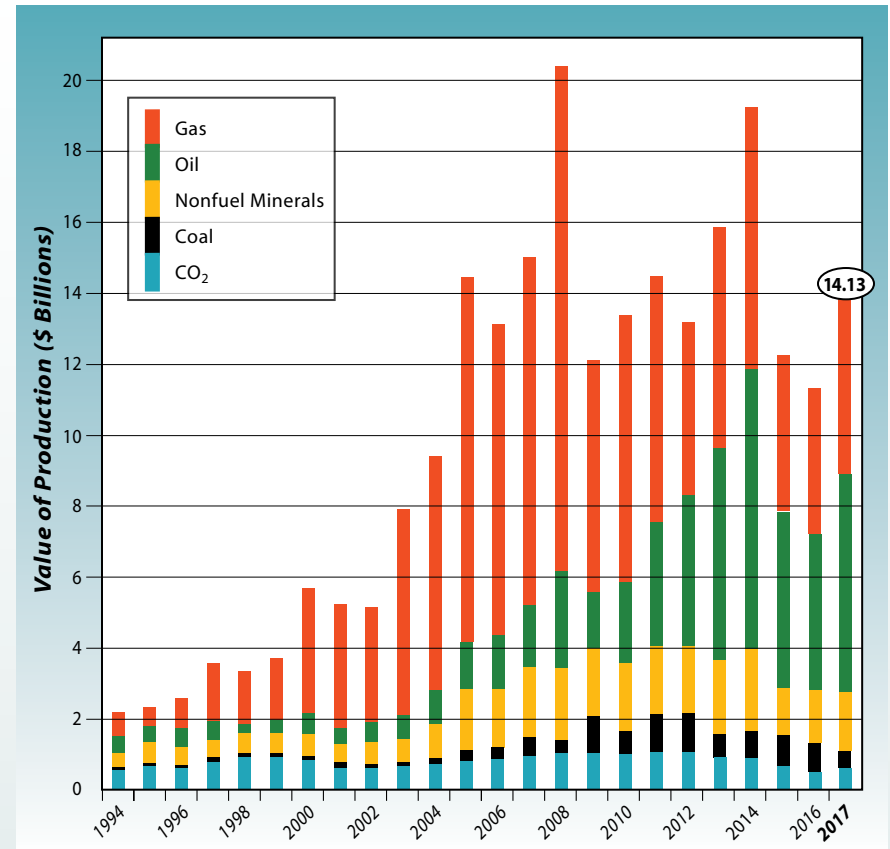
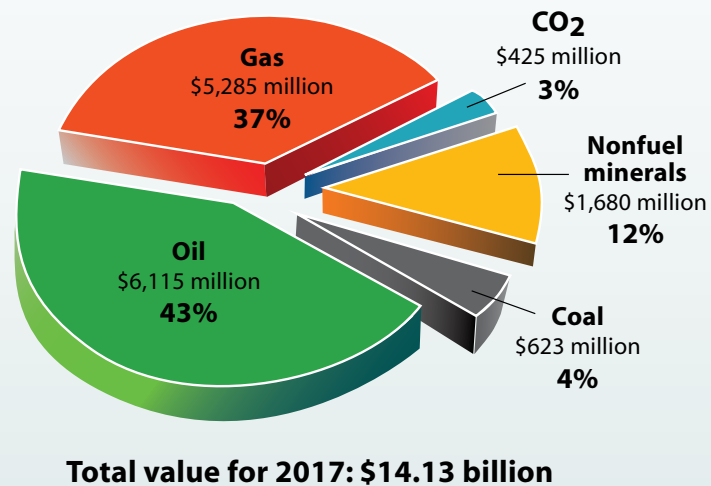


Figure ES-2. Mineral and energy fuel production value in Colorado, 1994–2017.

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

The total estimated value of oil and natural gas production in 2017 is \$11.4 billion. Colorado oil and natural gas production remains higher than historical values and production values have increased from 2016 primarily due to higher oil and natural gas prices. 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.

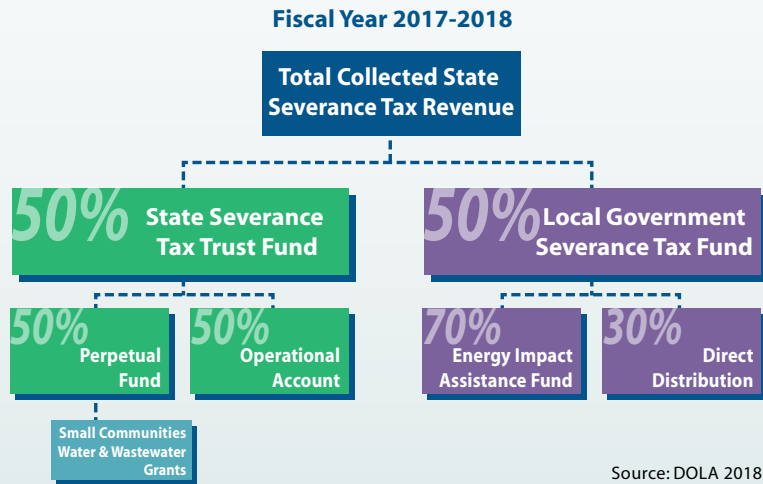
The estimated value of Colorado coal production in 2017 is \$623 million. Although coal production slightly increased in 2017, the overall decreasing trend in coal production is due primarily to the nationwide increased use of natural gas

and renewable energy. Colorado fell from the 11th largest coal producer in 2015 to the 13th largest coal producer in the U.S. in 2016, with both underground and surface mines currently in operation on the Western Slope.

Nonfuel mineral production includes metals, industrial minerals, and construction materials. The United States Geological Survey (USGS) estimates that the total value of Colorado's production of nonfuel minerals in 2017 is \$1.68 billion. Although just one mine in the state publicly reported gold production in 2017, Colorado remains the third largest producer of the metal in the U.S. Two Colorado mines continue to produce molybdenum and the state was the second largest producer of this metal in 2017.

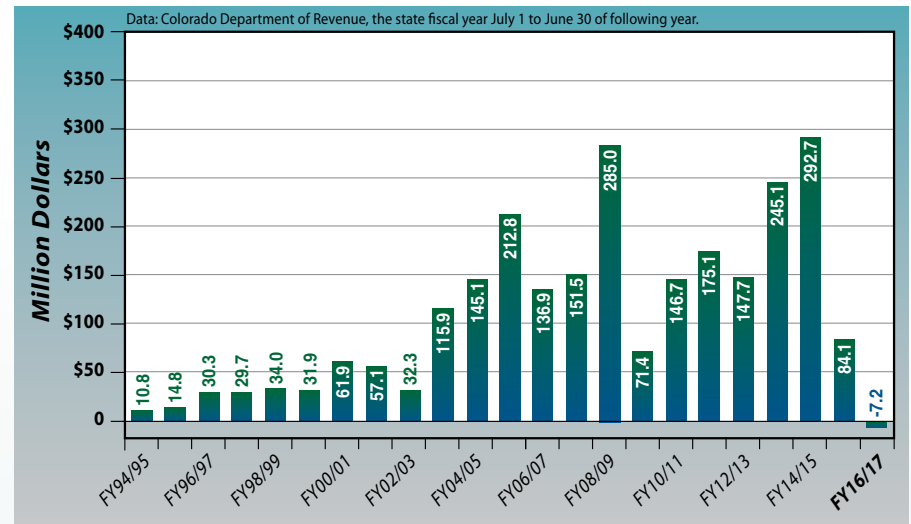
Carbon dioxide produced in Colorado is used primarily for enhanced oil recovery in the Permian Basin oil fields of Texas. The production value in 2017 was an estimated \$425 million. Although Colorado has been a producer in the past, there was no uranium mining in Colorado in 2017. Continued low uranium prices account for the lack of mining.

Severance taxes are state taxes collected on companies who produce nonrenewable resources including oil, gas, coal, molybdenum, and gold. Energy and mining companies who extract these resources pay severance as well as other taxes including income, sales, and property taxes. A portion of the severance tax funds are distributed to counties, municipalities, and school districts. Severance tax funds are also used to support the Colorado Geological Survey (CGS) and 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. Total collected state severance tax revenue in Colorado, 2017–2018.**

The Colorado Department of Local Affairs (DOLA) administers the distribution of severance tax revenue to affected county and local governments. In fiscal year (FY) 2016/2017 (16/17), July 1st thru June 30th, Colorado refunded an estimated \$14.3 million in severance taxes. **Figure ES-4** shows the annual severance taxes collected since 1994. The annual severance taxes collected in FY16/17 was estimated at minus \$7,195,425 due to the offset from other severance tax revenues besides oil and gas (e.g. minerals, coal, etc.).



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

Recent low levels of severance tax collections are caused by several factors. The ad valorem tax credit for State severance taxes is one factor. Oil and gas producers are able to claim a credit against severance taxes for property taxes paid, called the ad valorem credit. The credit has contributed to recent volatility in revenue. Property taxes on oil and natural gas are based on the prior year's production. Following a high production year, the amount of the ad valorem credit claimed is large because it is based on a higher production value. Oil and gas producers are then able to reduce severance taxes by a larger amount. This results in lower severance tax collections from lower production as well as the larger impact of the ad valorem credit.

Severance tax revenue has also been negatively impacted by an increase in amended returns filed in response to a 2016 Colorado Supreme Court ruling. Following the BP America v. Colorado Department of Revenue ruling, taxpayers can claim additional severance tax deductions related to certain costs incurred in their oil and gas extraction activities. In addition to lowering future severance tax collections, this decision also increased the refunds being made to severance taxpayers for past tax years. This is, as well as the ad valorem credit, the cause of the FY16/17 refunds reported by DOLA and discussed above.

In order to offset the impact of these tax refunds on state government funding, Senate Bill (S.B.) 16-218 was passed in 2016 that diverts amounts required from the General Fund reserve to make these reimbursements and restricts expenditures of severance tax money in various funds unless the restrictions are lifted, in



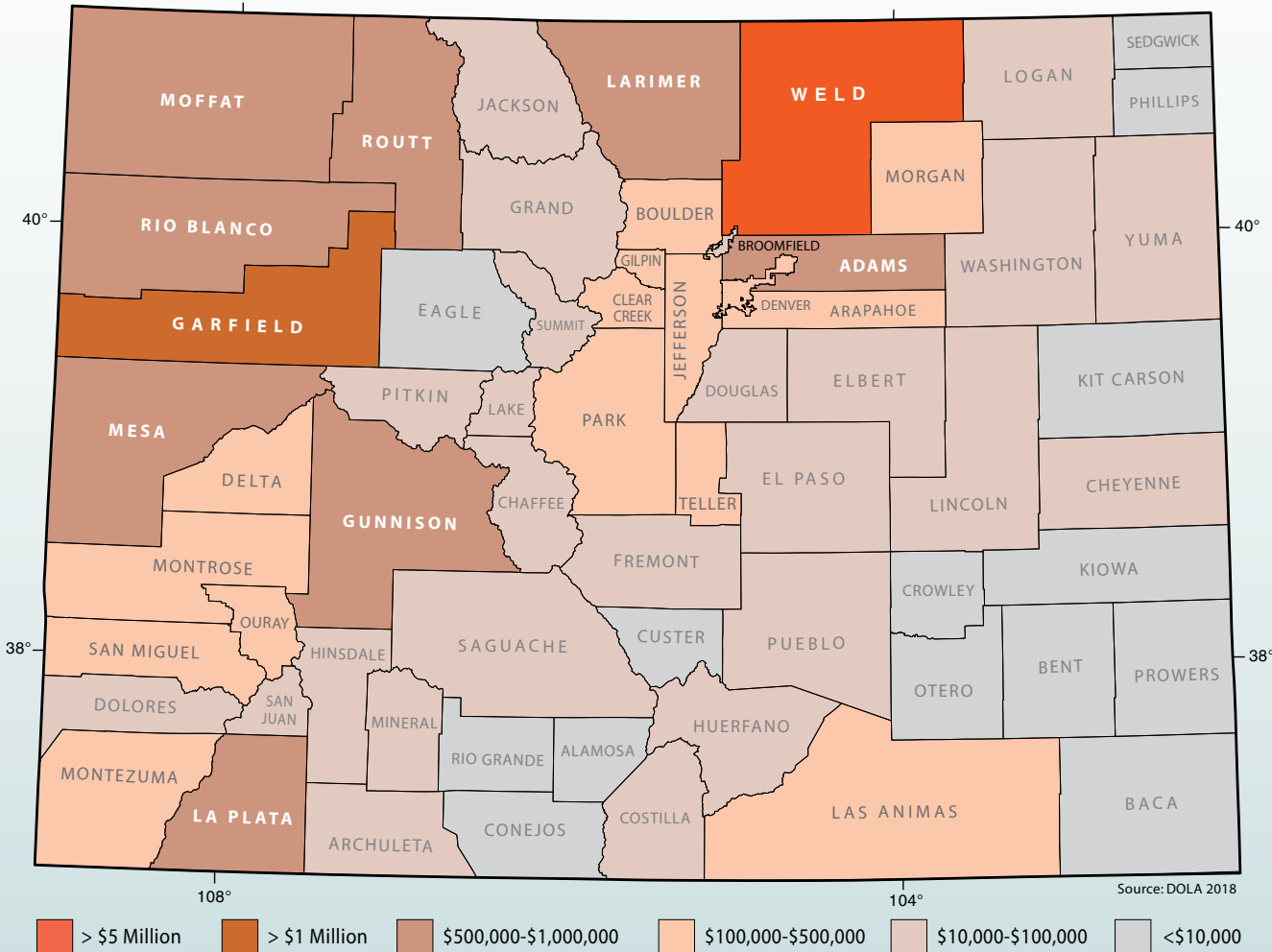
whole or part, by the Joint Budget Committee. Severance tax distributions were still made in FY16/17 to counties because required refunds were paid from a small portion of the gross severance tax collected in a month, capped at 15%, with the remaining balance refunded through the General Fund per S.B. 16-218. The map in **Figure ES-5** shows the distribution of severance taxes to each county.

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. In FY16/17, the SLB received \$94.9 million in mineral revenue. The revenues consisted of the following: oil and natural gas royalties and rentals, \$65.9 million; coal, \$6.7 million; minerals, \$2.0 million; and other revenues, \$20.3 million. **Figure ES-6** shows the State Land Board revenues from FY 1997 thru FY16/17.

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 FY17/18, mineral lease revenues totaled approximately \$86.9 million. **Figure ES-7** shows the revenue from federal mineral leases from 2009 to 2018.

### 2017 Severance Tax Distribution by County



**Figure ES-5. Colorado Mineral Severance Tax Distributions by County, fiscal year 2017.**

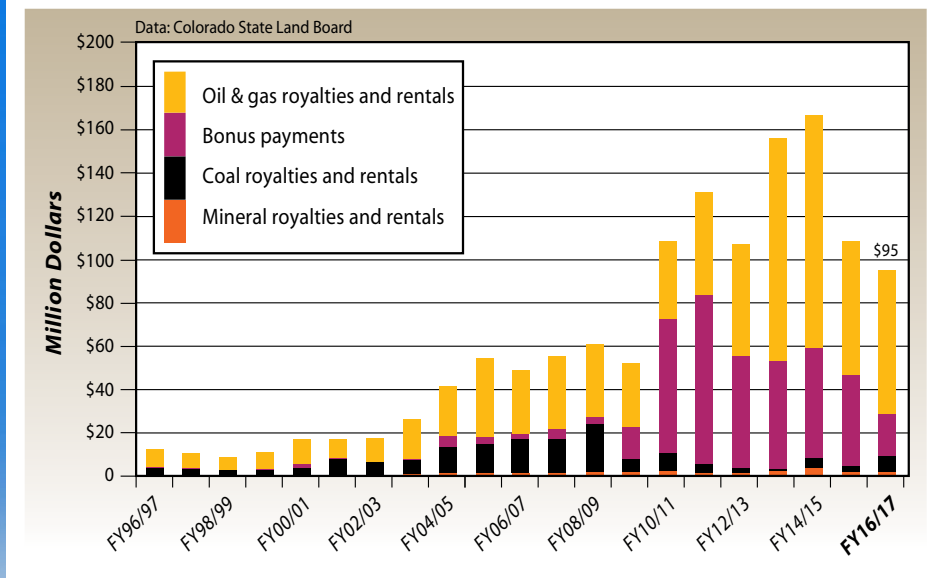


Figure ES-6. Colorado State Land Board (SLB) mineral revenues.

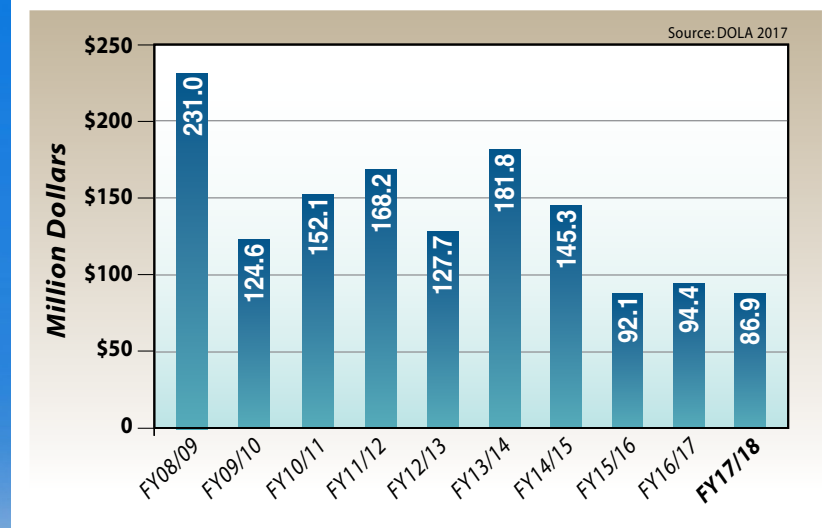


Figure ES-7. Colorado's share of federal mineral lease revenues.



Well operations, southeast of Grover, Weld Co Photo: M. O'Keefe



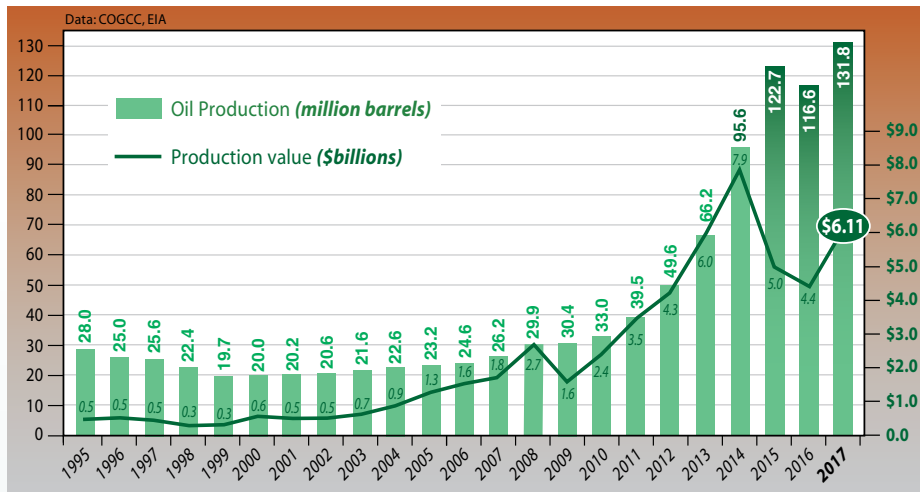


Figure 2. Oil production and production value in Colorado, 1995–2017.

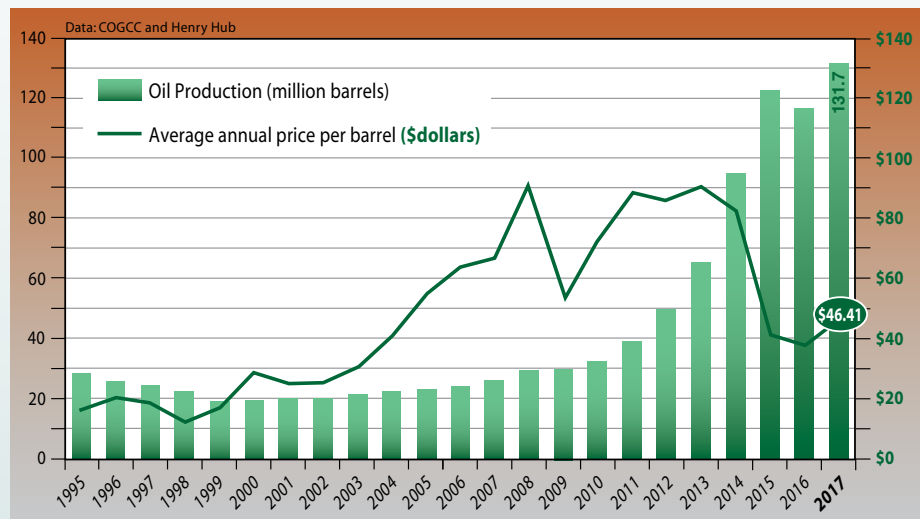


Figure 3. Colorado oil production and average annual price per barrel, 1995–2017.

Oil production in Colorado and the average annual price per barrel is shown in **Figure 3**. At the end of 2016, Colorado ranked eighth among the top ten states with proven oil reserves of 1.309 billion barrels of oil (BO) (**Figure 4**).

The 2017 average spot price for natural gas was \$3.10 per thousand cubic feet (Mcf) (based on a heat content of 1.037 British Thermal Units per Mcf

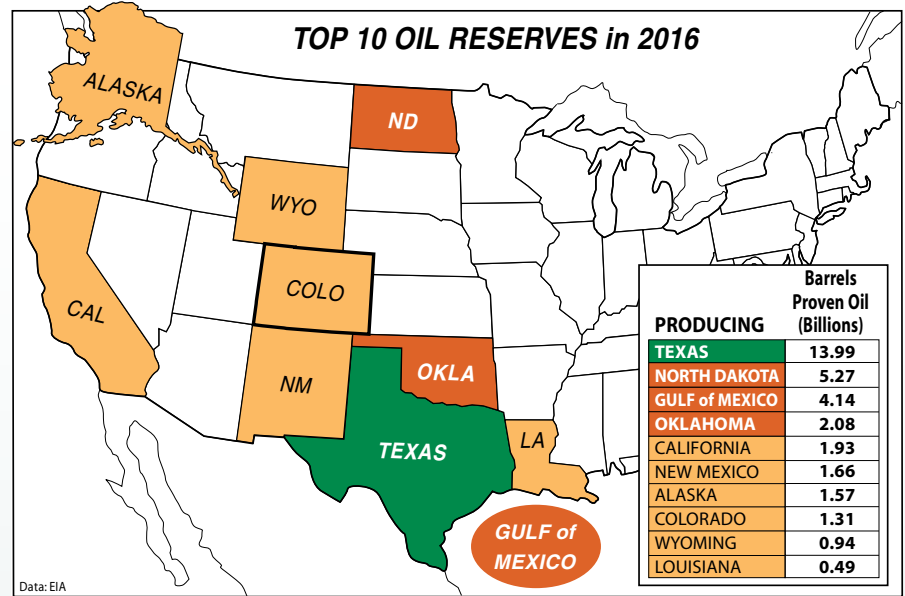


Figure 4. Top 10 states with proven oil reserves in 2016.

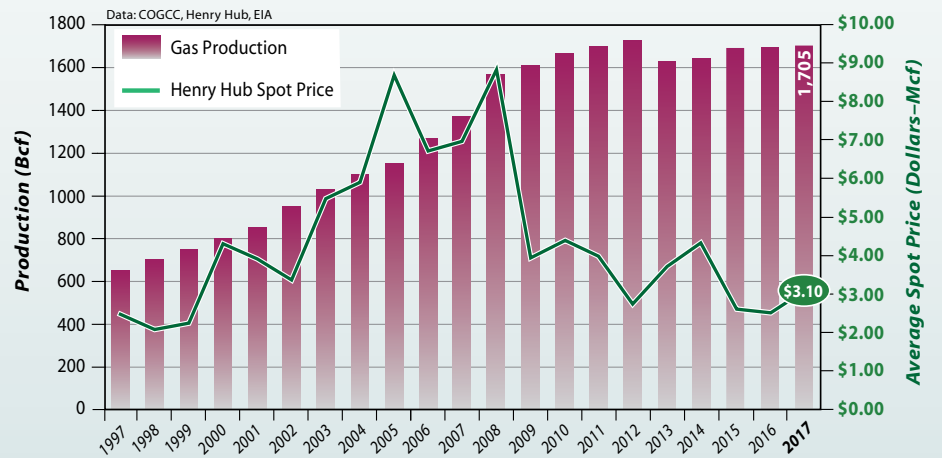


Figure 5. Colorado natural gas production and average spot price, 1997–2017.

(**Figure 5**). U.S. natural gas production increased between 2005 and 2017 which is consistent with the general decrease in price. The estimated total 2017 natural gas production value in Colorado is \$5.29 billion. In 2016, Colorado had proven natural gas resources of 19,086 billion cubic feet (Bcf), which was the sixth largest in the U.S. (**Figure 6**).

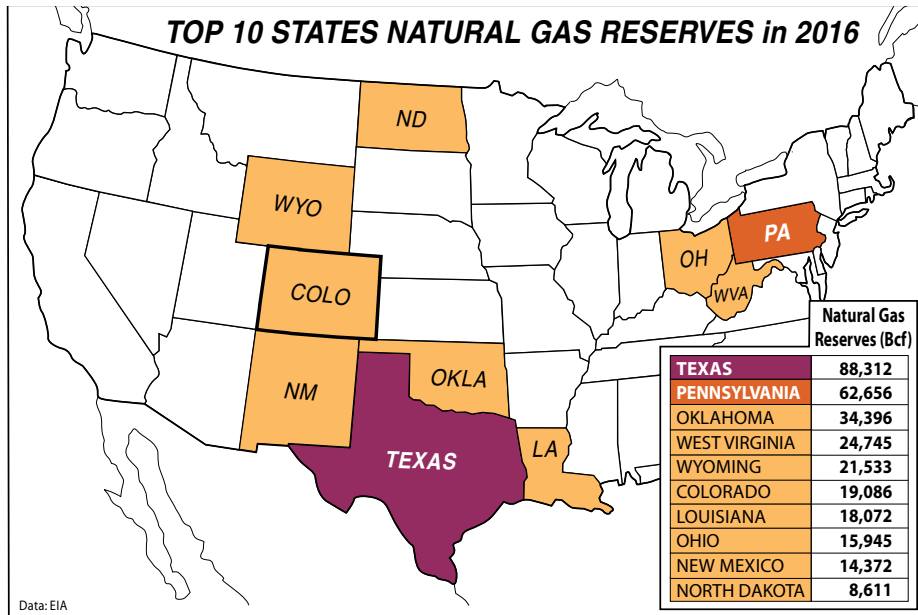


Figure 6. Top 10 states with proven natural gas reserves in 2016 (years end).

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 Tcf (trillion cubic feet) 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 which would connect this resource to the U.S. Pacific Northwest as well as to other countries. The proposed pipeline project is being reviewed by the Federal Energy Regulatory Commission and a decision is expected in late 2018.

### Coalbed Methane

Figure 7 shows the annual coalbed methane production versus conventional natural gas over time. Coalbed methane production reached its highest percentage of 59% of all natural gas production during 1998. The percentage share continuously declined to about 17% (290 Bcf) in 2017. This decline is largely due to the increase of production of unconventional reservoirs by the utilization of horizontal drilling and hydraulic fracturing techniques.

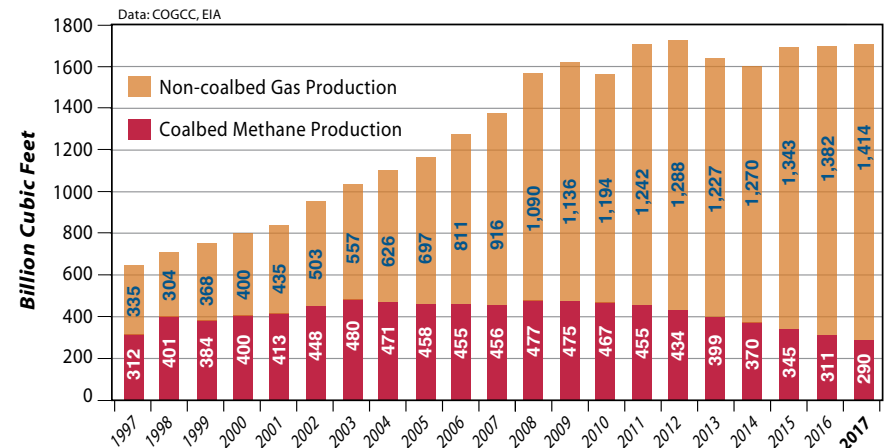


Figure 7. Coalbed methane vs. non-coalbed natural gas production in Colorado, 1995-2017.

### 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 \$46.41 per BO for the average annual price of oil and the average spot price for natural gas of \$3.10 per Mcf. The total 2017 estimated oil and natural gas production value for Colorado is \$11.4 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 about \$6.0 billion. Garfield County has the second largest natural gas and oil production value with an estimated total of \$1.6 billion. La Plata County ranks third in natural gas and oil production value with an estimated total of \$907 million. Rio Blanco, Las Animas, and Mesa counties have a combined oil and natural gas production value of \$682 million. Figures 9 and 10 show the estimated oil and natural gas production by county for 2017, respectively.

### Drilling Permits

Most new oil and natural gas drilling permits are still centered in Weld County, with lesser amounts in the other oil and natural gas producing counties. Colorado Oil and Gas Conservation Commission (COGCC) data indicate 3,578 drilling permits were approved in 2017, a 26 percent increase from 2016.



## 2017 Oil Production by County

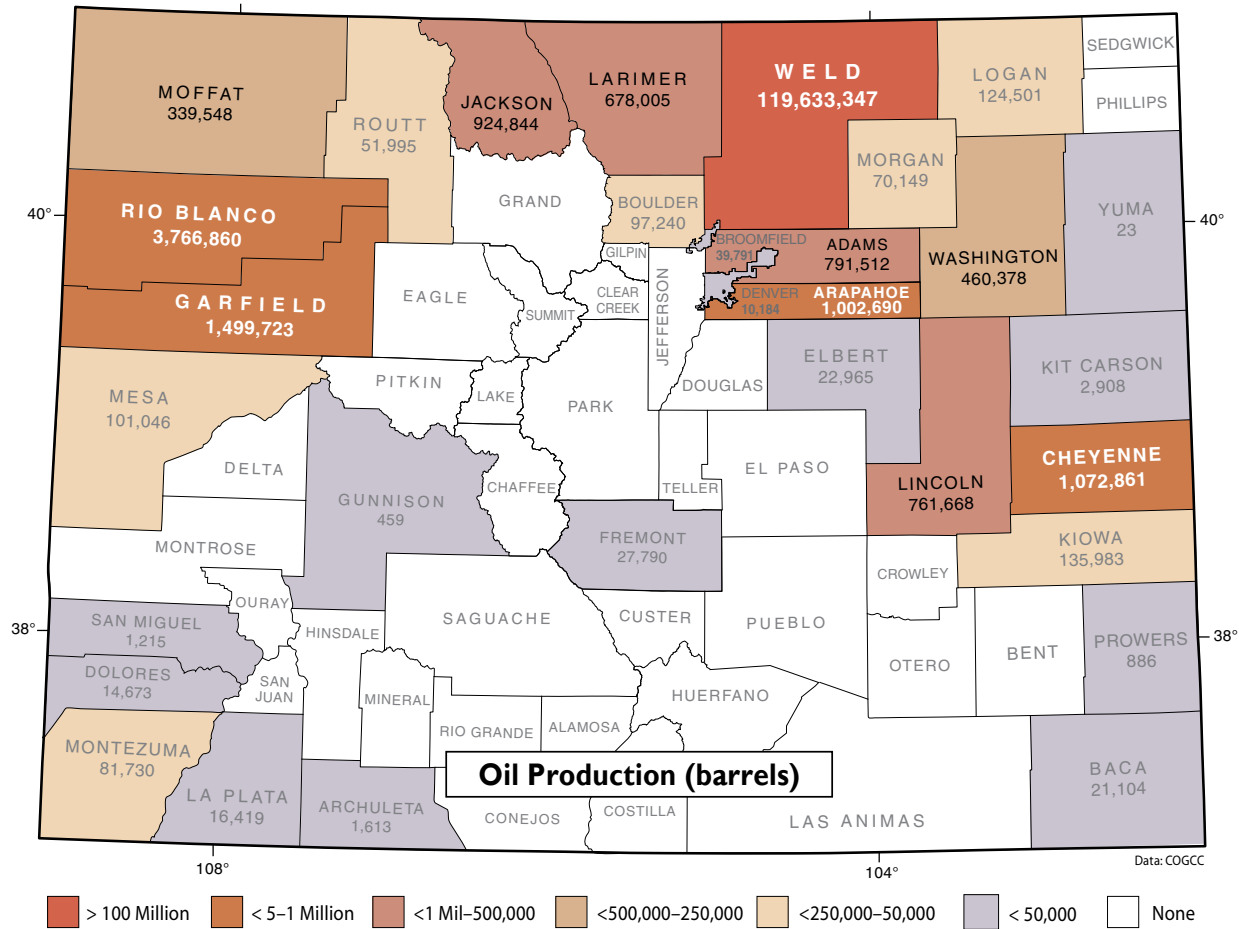


Figure 9. Total oil production by county in Colorado, 2017.



## 2017 Natural Gas Production by County

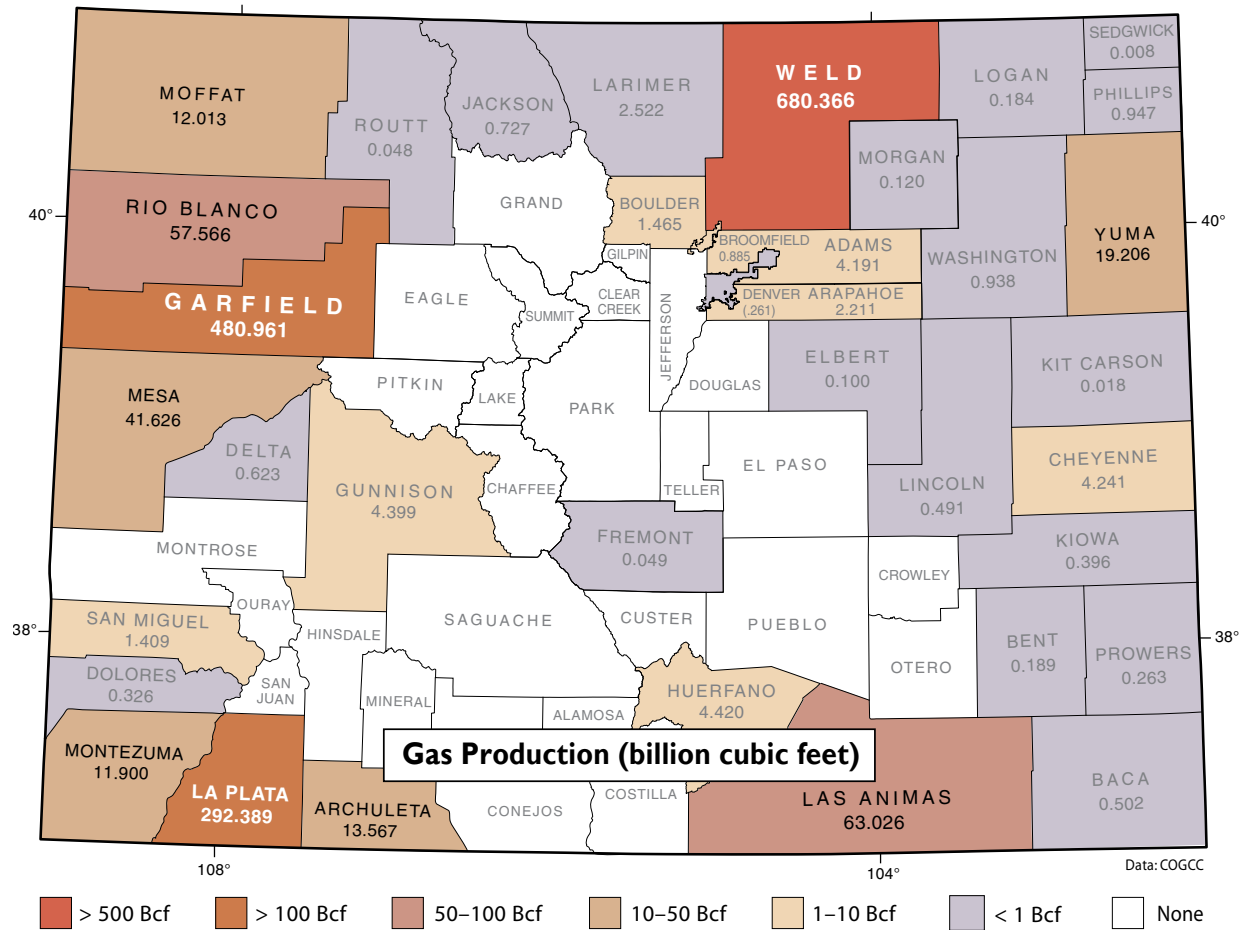
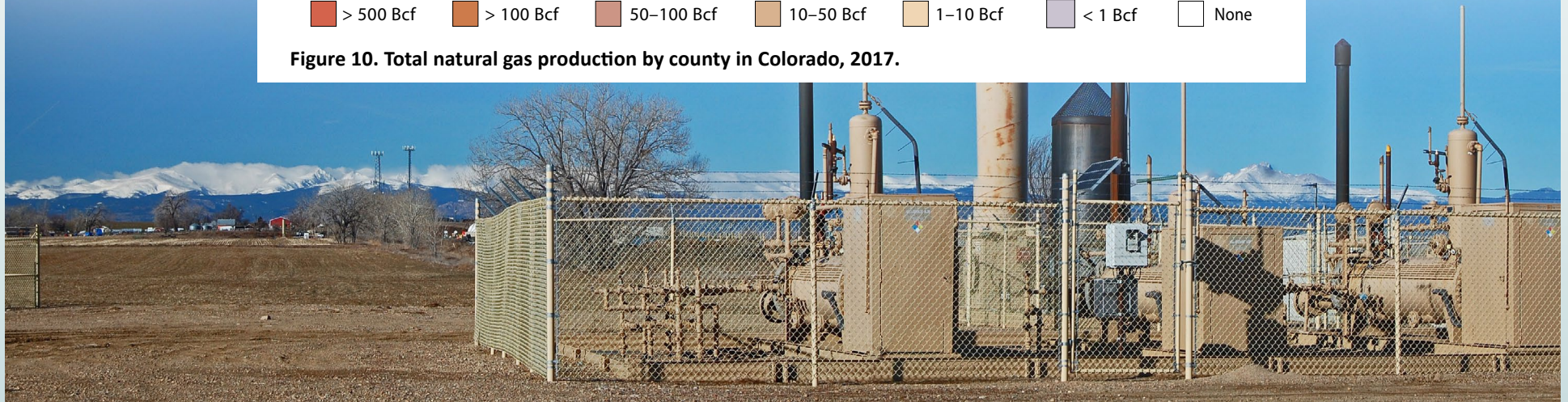


Figure 10. Total natural gas production by county in Colorado, 2017.





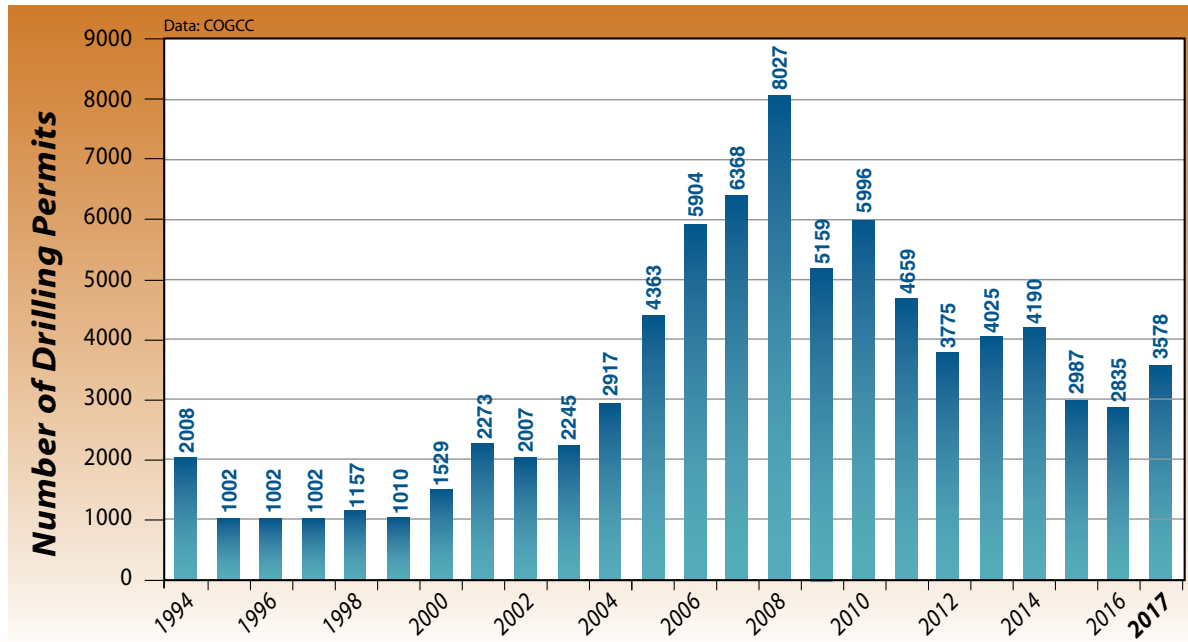


Figure 11. Annual oil and gas drilling permits in Colorado, 1994-2017.



# CONVENTIONAL ENERGY RESOURCES: COAL

Colorado coal continues to be a major source of the state's electrical power. According to the EIA, 48% of the electricity generated in Colorado in 2017 came from coal, 34% from natural gas, and 18% from renewables (e.g. wind, hydroelectric, and solar). 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. Typically, more than half of Colorado's coal is sold to out-of-state power companies. 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 less expensive and cleaner burning natural gas. About 531 coal units, within coal-fired plants, were retired in the U.S. between 2007 and 2016. Twenty-seven coal-fired plants totaling 22 gigawatts of capacity were scheduled for early closure or conversion in 2017.

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 then, the Arapahoe Station in Denver, the Clark Plant in Cañon City, and the Cameo power plant near Grand Junction were shut down between 2012 and 2013. Xcel Energy converted the last remaining coal-fired unit at the Cherokee Generating Station in Denver to natural gas in 2017. Also, in 2017, Xcel Energy 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).

Coal production from Colorado mines in 2017 is 15.18 million tons. The value of Colorado coal production in 2017 was \$623 million (**Table 1 and Figure 12**) and the estimated average value of a ton of Colorado coal was \$41. Colorado coal production and average prices since 2004 are shown in **Figure 13**. Employment in the Colorado coal mining industry in 2017 was 1,119 workers (**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 2016, Colorado was ranked 13th in coal production in the U.S. (**Figure 15**) down from 11th in 2015. 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**.

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

**Table 1. Coal production, price, value, and employment, 2001–2017.**



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	\$1,075	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	\$545	1,086
2017	15.18	\$41.00	\$623	1,119

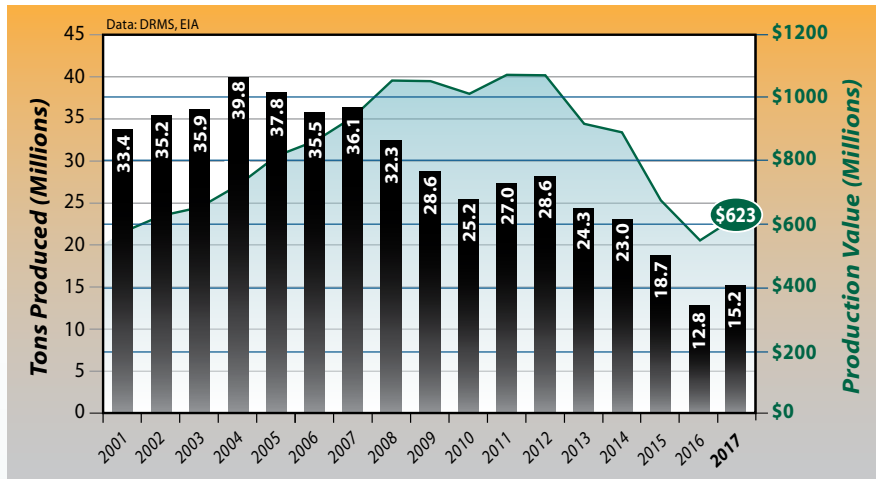


Figure 12. Production and value of coal mined in Colorado, 2001–2017.

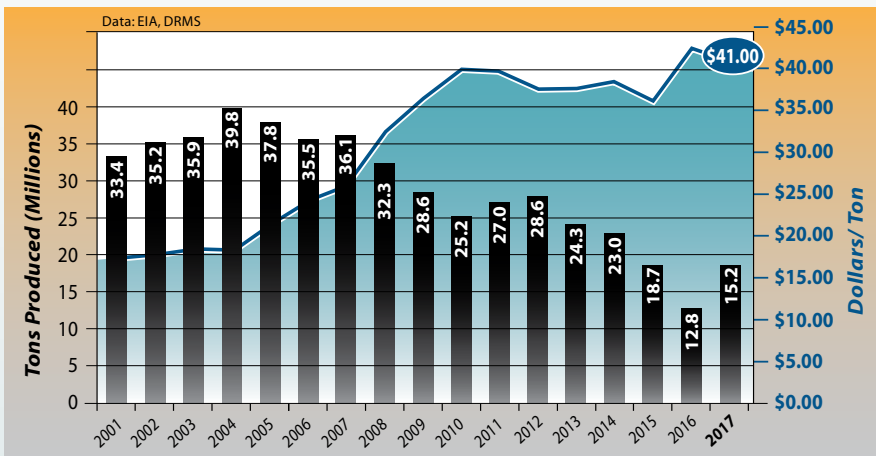


Figure 13. Coal production and average yearly coal price in Colorado, 2001–2017.

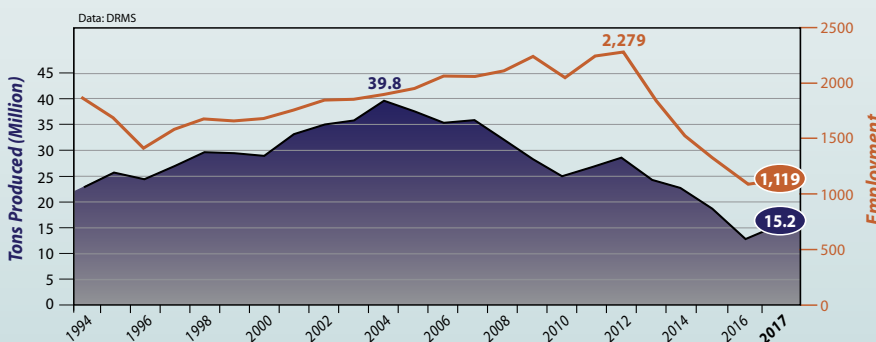


Figure 14. Coal production and employment in Colorado, 1994–2017.

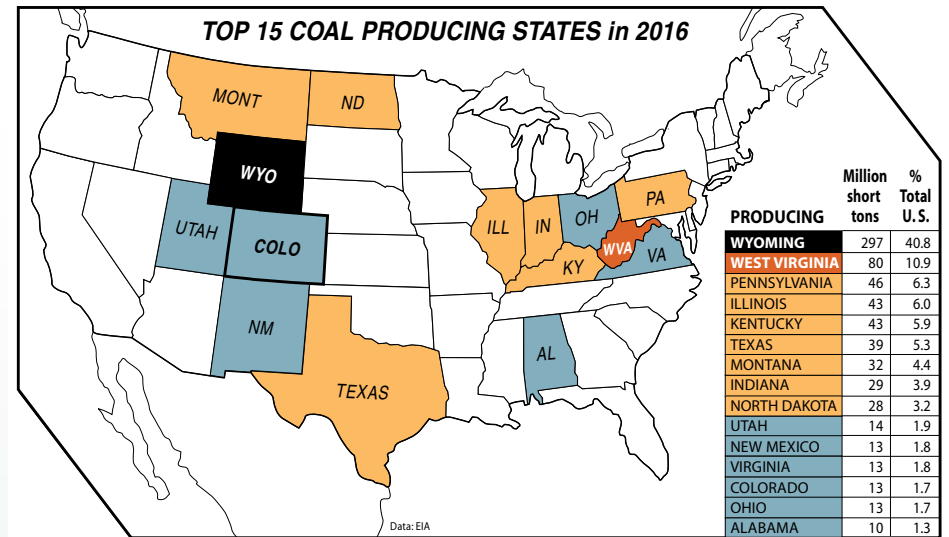


Figure 15. Top 15 coal producing states in 2016 (years end).

Seven Colorado coal mines were active in 2017, one less than in 2016 as the Bowie #2 remained idle in 2017. Also, New Horizon North only produced coal for six months and went to idle status beginning in June 2017 (Table 2). At the end of 2017, only six Colorado mines were active. Peabody Energy Corp emerged from bankruptcy in 2017 and owns the Foidel Creek (Twentymile) Mine in Routt County. Colowyo Mine in Moffat County is developing their Collum project which could extend the mine life over 30 years.

Table 2. Active coal mines in Colorado, 2017.

Mine	Operator	County	Mine Type	2017 Prod. (tons)
Bowie #2	Bowie Resources Ltd.	Delta	Underground	idle
Colowyo	Colowyo Coal Co. L.P.	Moffat	Surface	2,319,003
Deserado	Blue Mountain Energy	Rio Blanco	Underground	2,011,058
Foidel Creek	Twentymile Coal Co./Peabody	Routt	Underground	3,842,798
King II	GCC Energy National King Coal LLC.	La Plata	Underground	543,357
New Horizon North	Western Fuels-CO LLC	Montrose	Surface	31,299 (idle 6/17)
Trapper Strip	Trapper Mining Co.	Moffat	Surface	1,576,619
West Elk	Mountain Coal Co./Arch Coal	Gunnison	Underground	4,860,780
<b>Total</b>				<b>15,184,914</b>

Data: DRMS

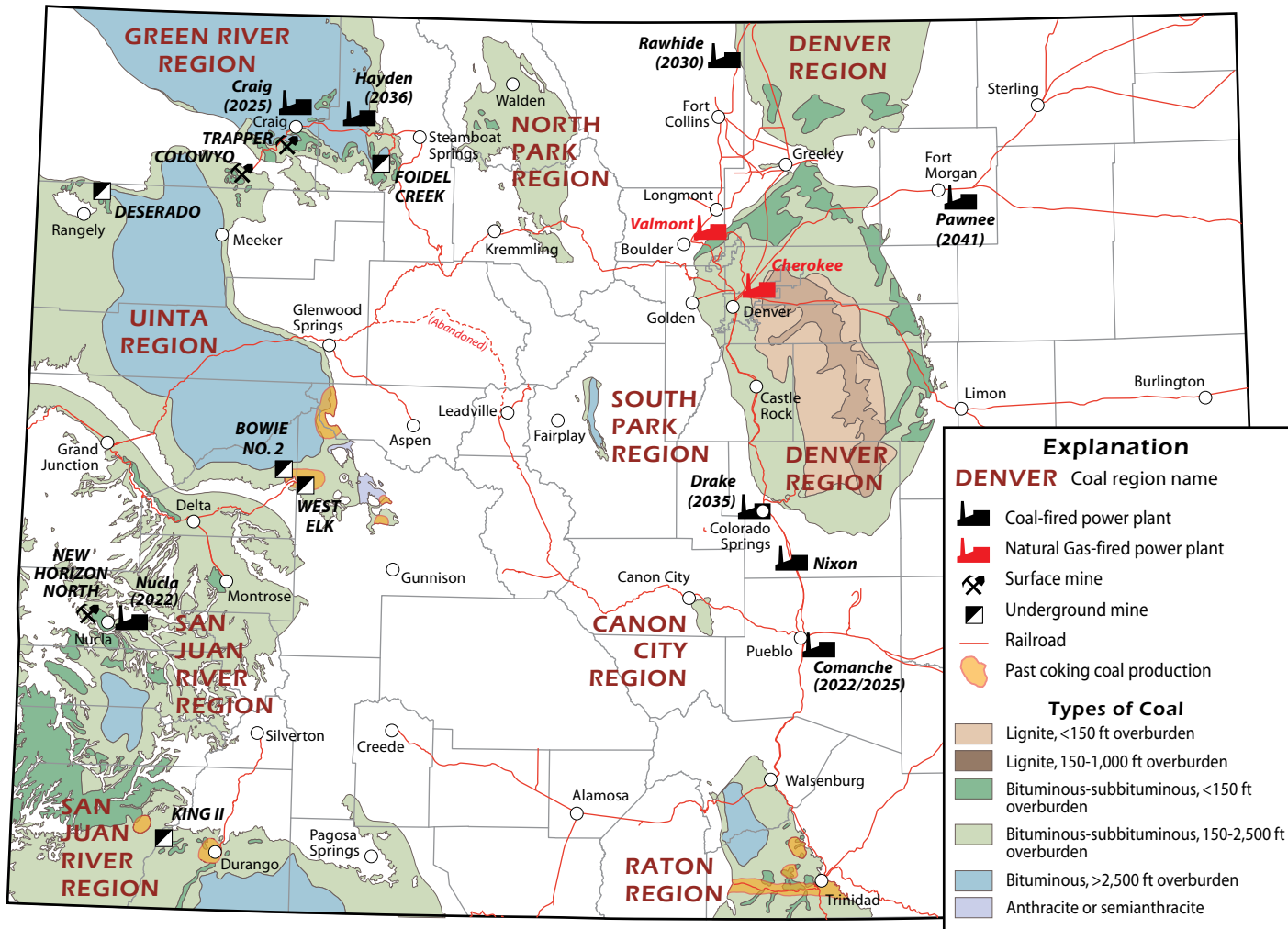
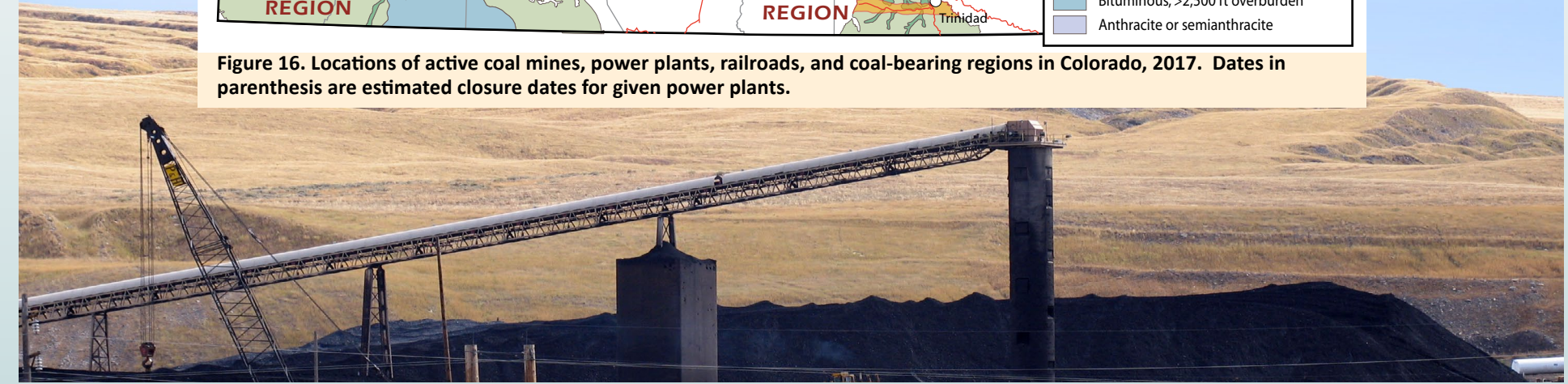


Figure 16. Locations of active coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2017. Dates in parenthesis are estimated closure dates for given power plants.



# CONVENTIONAL ENERGY RESOURCES: URANIUM

According to the Nuclear Energy Institute, nuclear energy accounted for 20% of U.S. electricity production in 2017. Colorado is one of about twenty states that did not generate electricity from nuclear energy. **Figure 17** shows the average annual uranium prices in the U.S. since 2002. Generally, prices have been trending downward since 2007 and after the 2011 Fukushima, Japan accident. Although Colorado has been a producer of uranium in the past, there are currently no producing uranium mines or mills in Colorado. In 2017, U.S. production was from one mill in Utah and in-situ leaching operations in Wyoming and Nebraska. **Figure 18** shows the estimated annual production of uranium concentrate in the U.S. between 1996 and 2017.

According to the EIA, uranium exploration and development drilling activity for the U.S. decreased from 0.8 million feet in 2016 to 0.2 million feet of drilling in 2017. Estimated uranium exploration and development expenditures decreased from \$22.3 million in 2016 to \$4 million in 2017. The proposed Pinon Ridge uranium mill located in Montrose County is on hiatus because their radioactive materials license was declined by the Colorado Department of Public Health and Environment due to a court ruling. The court determined that Energy Fuels Inc. failed to demonstrate adequate protection of human health and the environment. Even though a number of mines are located in Colorado, there was little activity reported from these facilities. In 2018, Pedro Resources Ltd. announced their acquisition of the Graysill Mine Property located in San Juan and Dolores Counties. The Graysill Mine was a past producer of vanadium and uranium in the 1940s and 50s. Western Uranium Corporation recently announced plans to re-open the Sunday Mine Complex in San Miguel County. The complex consists of five mines and 221 unpatented claims covering about 3,800 acres. Additional information associated with uranium-vanadium properties is discussed in the vanadium section of this report under Other Exploration and Development Activities.

In 2017, about 93% of uranium delivered to U.S. reactors came from other countries including Canada (35%), Australia (20%), Russia (18%), Kazakhstan (12%), Uzbekistan (5%), and others (10%). In 2018, uranium was listed as a critical mineral by the USGS as discussed in the Critical Mineral section of this report. Also in 2018, the U.S. Secretary of Commerce launched an investigation to determine if the current circumstances associated with uranium U.S. imports threatens to impair national security.

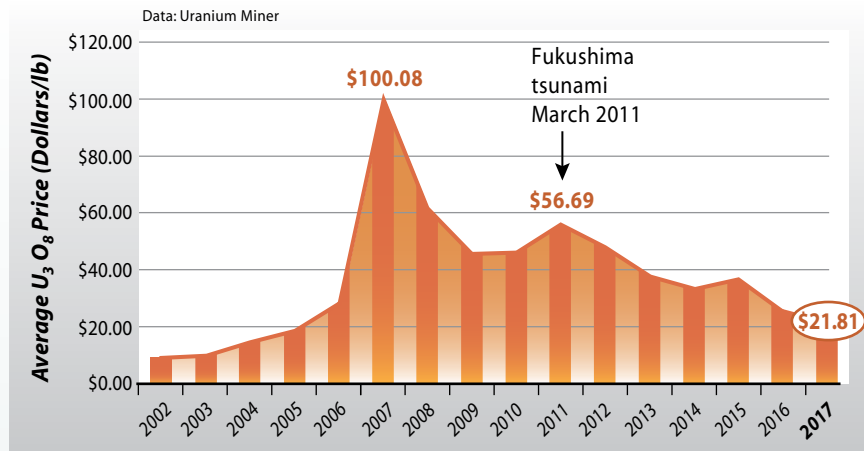


Figure 17. Average annual U<sub>3</sub>O<sub>8</sub> price per pound in U. S., 2002–2017.

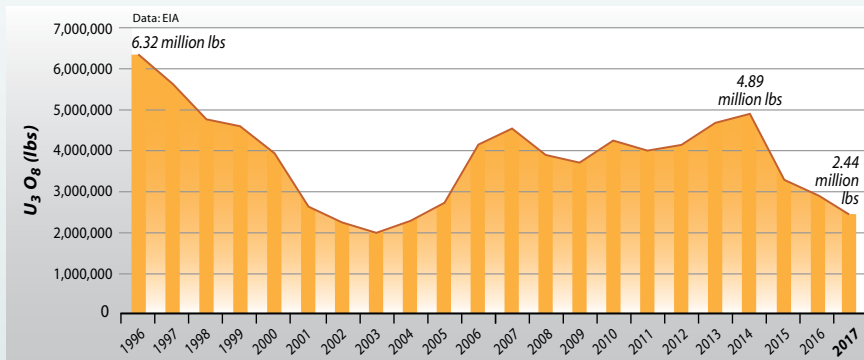
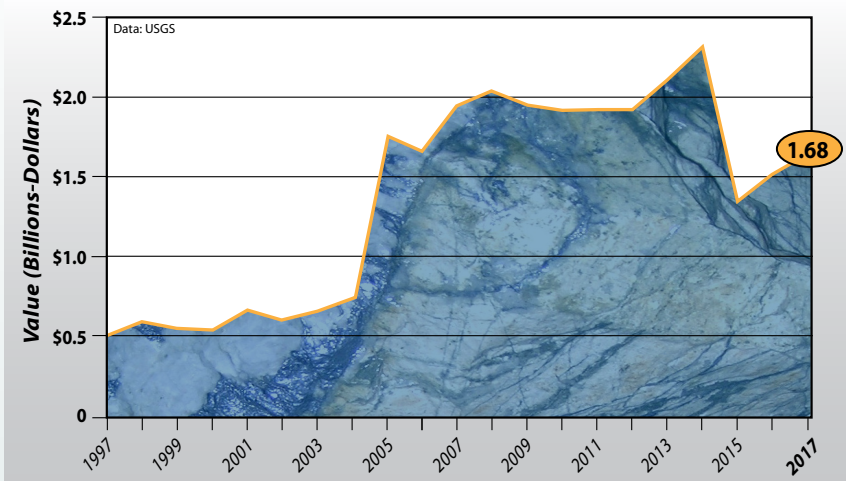


Figure 18. Annual production of uranium concentrate in U. S., 1996–2017.

# NON-FUEL MINERAL RESOURCES

Nonfuel mineral resources include metals, industrial minerals, and construction materials (e.g. cement, lime, sand, and gravel). The USGS estimates that the total U.S. 2017 nonfuel mineral production value was \$75.2 billion, a 6% increase from last year. Colorado ranked 14th in U.S. nonfuel mineral production value for 2017 and produced \$1.68 billion, or about 2.23% of the estimated total production value. **Figure 19** shows the nonfuel mineral production value in Colorado over time.



**Figure 19.** Total nonfuel mineral production value in Colorado, 1997–2017.

## Metal Mining

Metals mined in Colorado include gold, molybdenum, and silver. The CGS estimates that the 2017 production value of gold and molybdenum in Colorado was \$831 million. Silver production values for Colorado were unavailable.

## Molybdenum

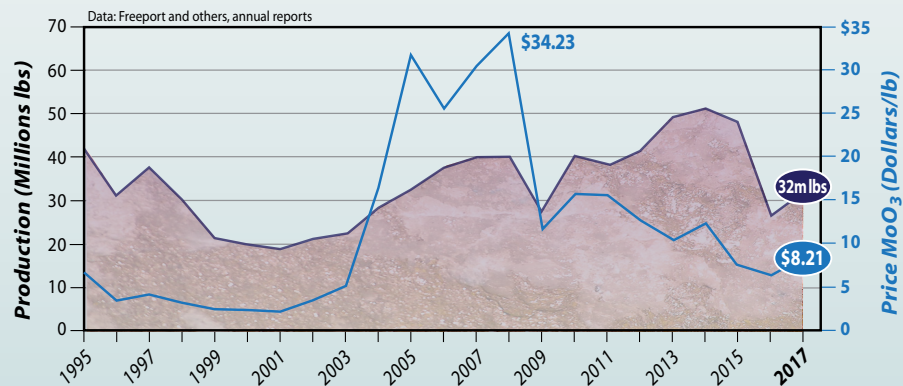
Molybdenum is primarily used to produce engineering steels (e.g. superalloys, nickel alloys, and tool steels), stainless steel, molybdenum metal and other alloys, catalysts, pigments, corrosion inhibitors, smoke suppressants, lubricants, and chemicals. According to the USGS, the U.S. is the third largest producer of molybdenum in the world and produced an estimated 98 million pounds in 2017, valued at an estimated \$800 million, based on average prices. This is approximately 25% higher than the 2016 estimated production of 79 million

pounds and was likely due to higher prices. China is the top producer (estimated 287 million pounds in 2017) and Chile is the second largest producer (estimated 128 million pounds in 2017).

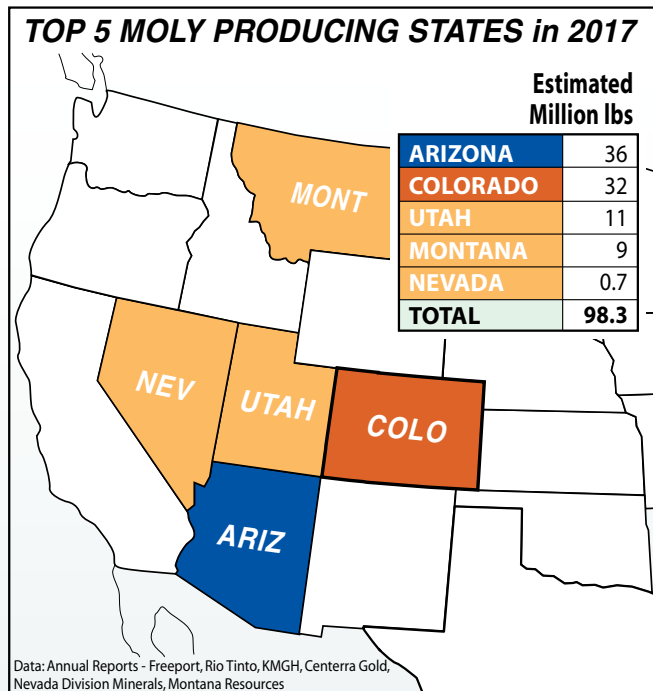
Colorado's annual production and average annual price per pound for molybdenum trioxide ( $\text{MoO}_3$ ) are shown in **Figure 20**. Higher production in Colorado was mainly due to higher molybdenum prices over the last year. A majority of the 2017 primary molybdenum production in the U.S. was from two Colorado mines that produced approximately 32 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). The Climax Mine is located northeast of Leadville, at Fremont Pass, and includes a 25,000 metric 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. Climax molybdenum production was approximately 23 million pounds in 2015, 16 million pounds in 2016, and 20 million pounds in 2017. At the end of 2017, proven reserves at the Climax mine were estimated at 162 million tons with an average ore grade of 0.16% molybdenum.

The Henderson Mine, located near Empire in Clear Creek County, has been in operation since 1976. This operation is a large block-cave underground mine



**Figure 20.** Molybdenum production and average annual price per pound in Colorado, 1995–2017.



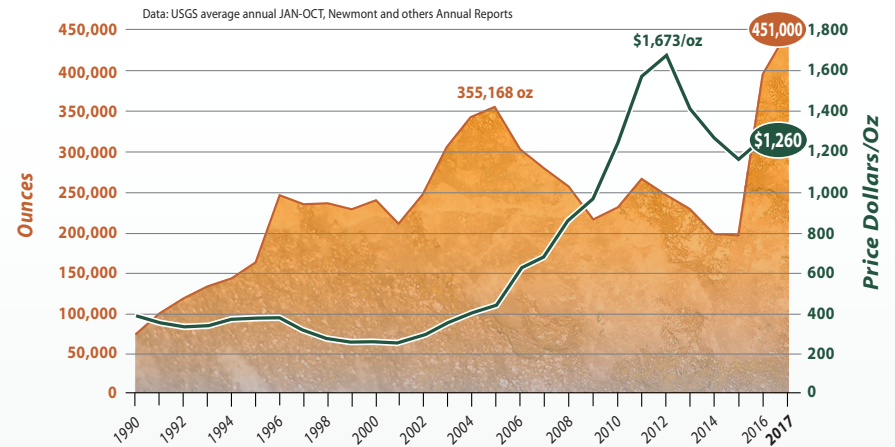
**Figure 21. Top five molybdenum producing states, 2017.**

connected to a 35,300 tons per day concentrator in adjoining Grand County by a 15-mile conveyor. Henderson molybdenum production was approximately 25 million pounds in 2015, 10 million pounds in 2016, and 12 million pounds in 2017. At the end of 2017, proven reserves at the Henderson mine were estimated at 66 million tons with an average ore grade of 0.18% molybdenum.

### Gold and Silver

According to the USGS, U.S. gold production increased from 245 tons (7.8 million ounces) in 2016 to an estimated 270 tons (8.6 million ounces) in 2017 with an estimated value of \$9.9 billion. In 2017, the U.S. was the fourth largest producer of gold in the world following China (485 tons), Australia (331 tons), and Russia (281 tons). **Figure 22** shows the price of gold and Colorado gold production from 1990 to 2017. Colorado was the third top producer of gold (451,000 ounces) in the U.S. (**Figure 23**) following Nevada (about 5,640,000 ounces) and Alaska (about 895,164 ounces) in 2017. The average gold price in 2017 was \$1,260 per ounce.

In August of 2015, Newmont Mining Corporation (Newmont) acquired the Cripple Creek and Victor Gold Mining Company (CC&V), located near the town of Victor. Newmont was the second largest producer of gold in the world in 2017.



**Figure 22. Colorado estimated gold production and average annual price per ounce, 1990–2017.**

Their corporate headquarters is located in the Denver area. CC&V produced an estimated 451,000 ounces of gold in 2017, about 14% higher than the 396,000 ounces of gold estimated in 2016. Silver is also produced from CC&V, however, Newmont did not have estimates of the ounces produced in 2016 and 2017. Prior to the Newmont acquisition, CC&V produced just over 100,000 ounces of silver per year between 2011 and 2014.



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

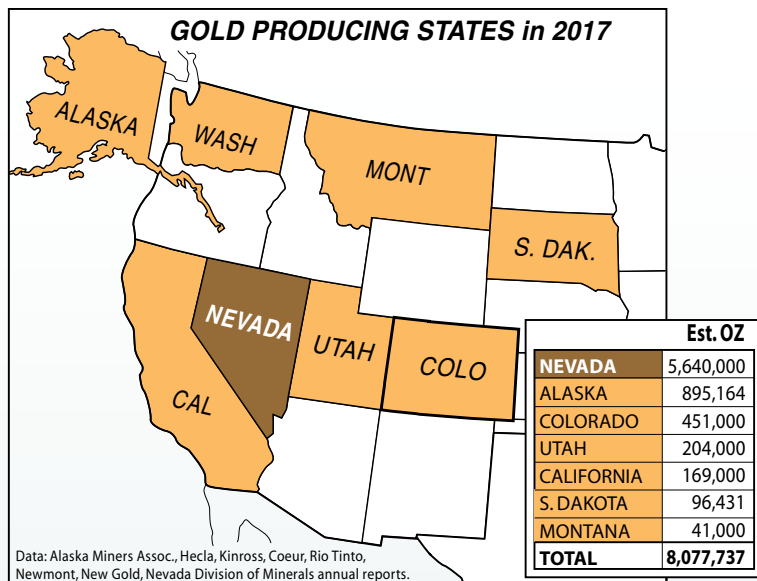


Figure 23. Major gold producing states in 2017.

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 35 active mining permits with gold listed as the mined commodity in the Colorado Division of Reclamation, Mining and Safety (DRMS) database.

In 2017, Ouray Silver Mines LLC (OSM), owned by Lascaux Resource Capital (Lascaux), continued to develop the Revenue-Virginus Mine for potential start-up. In 2018, Aurcana Corporation announced that it would acquire OSM from Lascaux. The mine will produce primarily silver, predominately 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. Reportedly, the mine flooded in 1906. OSM reports proven and probable reserves of 21.2 million ounces at a silver equivalent grade of 36.9 ounces per short ton.

### Other Exploration and Development Activities

S&P Global Market Intelligence reported that 2017 worldwide exploration budget estimates for nonferrous metals were up 15% from the 2016 total. The 2017 estimated global exploration budget for nonferrous metals was \$8.4 billion.



The historic Revenue Mine site remains sit above Sneffels Creek outside of Ouray.

Exploration and development projects that have undergone at least some recent activity are discussed below. Past CGS MEIA reports have updates associated with other properties including the Dawson Project, Golden Wonder Mine, San Juan Silver Project, and Klondike Mine.

**The Silver Cliff Property** is located in the Hardscrabble Silver District, a historic silver-lead-zinc mining district, near Silver Cliff in Custer County. Viscount Mining Corp. (Viscount) began exploration at the property in 2016 for silver, which included geophysical surveying, detailed mapping, and drilling. Viscount reported that their 2016 drilling shows silver mineralization is predominantly hosted in an altered tuff associated with the Silver Cliff caldera. In 2018, Viscount announced the signing of an agreement to acquire leases on 22.5 additional acres of patented claims and is currently planning to drill and expand the indicated and inferred mineral resource of 12,704,800 ounces of silver announced earlier this year.

**The Tomichi Copper-Molybdenum** project consists of about 49 unpatented lode claims east of Gunnison that contain copper-molybdenum mineralization associated with Proterozoic granites intruded by a Paleogene granitic intrusive complex. Reportedly, the deposit is thought to be a porphyry copper-molybdenum deposit and includes several intrusions, zoned hydrothermal alteration, and multiple stages of veins and sulfide mineralization. A technical report released in 2017 by Libero Mining Corporation, a Canadian based company, indicates that the Tomichi deposit contains an inferred mineral resource with 711 million



metric tons at the following grades: 0.21% copper, 0.035% molybdenum, 0.017 grams per ton gold, 2.0 grams per ton silver, and 0.22 grams per ton rhenium.

**Lithium** is used in ceramics, glass, batteries, 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. Lithium battery production will likely increase due to the increase in demand for electric and hybrid vehicles, electric tools, portable electronics, and energy storage grids. In 2017, the main producers of lithium included Australia, Chile, and Argentina. According to the USGS, the only 2017 production of lithium in the U.S. 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 also occur in the Paradox Basin which straddles the Colorado-Utah border in southwestern Colorado. The Paradox Basin brines in Colorado potentially host economic deposits of lithium, bromine, and potassium associated with evaporates in the Paradox Formation located within the basin.

In 2017, New Tech Lithium Corporation (New Tech, previously known as American Potash Corporation) acquired 608 federal lithium and bromine placer mining claims in San Miguel County, totaling approximately 12,160 acres, in two areas overlying the southeast extension of Paradox Formation evaporite beds. These two areas include southeast Lisbon Valley and Andy's Mesa further to the east. New Tech observed elevated lithium concentrations within subsurface brines during potash exploration in the area. According to New Tech, lithium-bearing brines have been documented in historic oil and gas wells, and one potash exploration well, in this region. In 2017, New Tech was in negotiations with oil and gas well-field lease owners and operators to access and sample co-produced brines produced from their oil and gas production to provide general information about the lithium concentrations in this area and to guide future exploration efforts.

**Vanadium** in Colorado is generally associated with the sandstone-hosted uranium deposits located in western Colorado, specifically on the Colorado Plateau. There are currently no mines in production and the last vanadium production reported in Colorado was in 2005. If Colorado uranium mining resumes in the future, vanadium would likely be produced as a by-product. Uranium and vanadium were listed as critical minerals by the USGS in 2018. Average vanadium prices reported by the USGS increased from \$3.38 per pound of vanadium pentoxide in 2016 to \$5.20 per pound in 2017. In 2017, 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. In 2017, China, Russia, and South Africa were the top three producers of vanadium.

In 2018, Anfield Energy Inc. (Anfield, previously Anfield Resources) reported that it had identified potential vanadium targets in Colorado and Utah after purchasing an exploration database of mining projects in the western United States focused primarily on uranium and vanadium properties. Anfield is a uranium and vanadium development company and owns the Shootaring Canyon Mill, a licensed uranium mill, located in Utah, other uranium assets in Utah and Arizona, and historic uranium producing claim groups in Mesa, Montrose, and San Miguel Counties in Colorado.

United Battery Metals Corporation (United Battery, formerly United Lithium), acquired rights to the Wray Mesa project in western Montrose County which includes a uranium/vanadium property. The property reportedly consists of 37 unpatented mining claims covering about 760 acres that encompasses historic uranium and vanadium exploration and mining within the La Sal Creek mining district. In 2018, United Battery announced plans to conduct an initial exploration program to identify drill targets. Later in 2018, United Battery announced they acquired additional claims in the area extending into Utah.

## Critical Minerals

The Presidential Executive Order (E.O.) No. 13817 dated 20 December 2017 and entitled "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," ordered the creation of a critical minerals list as follows:

*"Secretary of the Interior, in coordination with the Secretary of Defense and in consultation with the heads of other relevant executive departments and agencies (agencies), shall publish a list of critical minerals in the Federal Register not later than 60 days after the date of this order, and disseminate such list to the appropriate agencies."*

A critical mineral, as identified by the Secretary of the Interior (SI) in coordination with the agencies, was defined as a:

- 1.) non-fuel mineral or mineral material essential to the economic and national security of the U.S.,
- 2.) the supply chain of which is vulnerable to disruption and,
- 3.) 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.

Furthermore, the policy of the federal government is to:

- 1.) reduce vulnerability to disruptions in the supply of these critical minerals by identifying new sources of critical minerals,
- 2.) increase the activity of the supply chain at all levels (e.g. exploration, mining, concentration, separation, alloying, recycling, and reprocessing),
- 3.) ensure that miners and producers have electronic access to advanced topographic, geologic, and geophysical data (to the extent permitted by law, etc.), and
- 4.) streamline lease and permit processes to expedite the activity of the supply chain for critical minerals at all levels.

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.

Pursuant to E.O. 13817, the SI published a draft list of critical minerals in February 2018 consisting of the following 35 minerals or mineral material groups deemed critical by the definition provided above (in alphabetical order):

**Aluminum (bauxite), antimony, arsenic, barite, beryllium, bismuth, cesium, chromium, cobalt, fluorspar, gallium, germanium, graphite (natural), hafnium, helium, indium, lithium, magnesium, manganese, niobium, platinum group metals, potash, the rare earth element (REE) group, rhenium, rubidium, scandium, strontium, tantalum, tellurium, tin, titanium, tungsten, uranium, vanadium, and zirconium.**

This draft list was later confirmed in May 2018 by the SI in the federal register. 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). The USGS methodology for determining the draft critical mineral list is documented in USGS Open-File Report 2018-1021 entitled, “Draft Critical Mineral List – Summary of Methodology and Background Information – U.S. Geological Survey Technical Input Document in Response to Secretarial Order No. 3359.” 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.”

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, REE, lithium, potash, as well as other critical minerals that may be economical to extract. The CGS is currently working on providing more information on critical minerals in Colorado.

*Gallium, germanium, indium and tellurium are all critical minerals used in photo-voltaic technology. Solar array in the San Luis Valley. Photo:hopkins/neoscenes ©2019*



# AGGREGATE – SAND, GRAVEL, AND CRUSHED STONE

The primary uses of sand and gravel are concrete aggregates, road base, road coverings/stabilization, construction fill, asphaltic concrete and other bituminous mixtures, construction fill, and other concrete products. Other uses include plaster and guniting 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. For 2017, DRMS lists over 1,000 active permits for sand, gravel, aggregate, and aggregate-related quarries in Colorado.

The USGS estimates that Colorado quarry operators produced 55.6 million tons of aggregate (sand, gravel, and crushed stone) in 2017 (Figure 24). The estimated 2017 production value was \$301 million for sand and gravel and \$182 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”

(Cappa, 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>

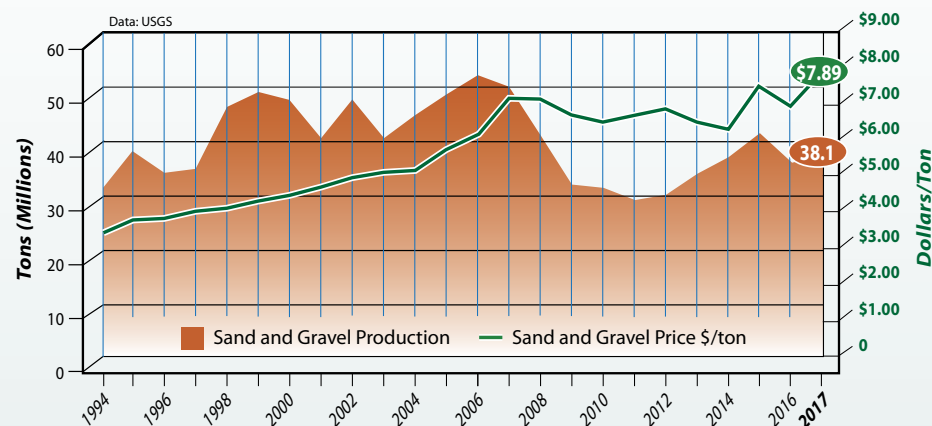


Figure 25. Price and production of sand and gravel aggregate in Colorado, 1994–2017.

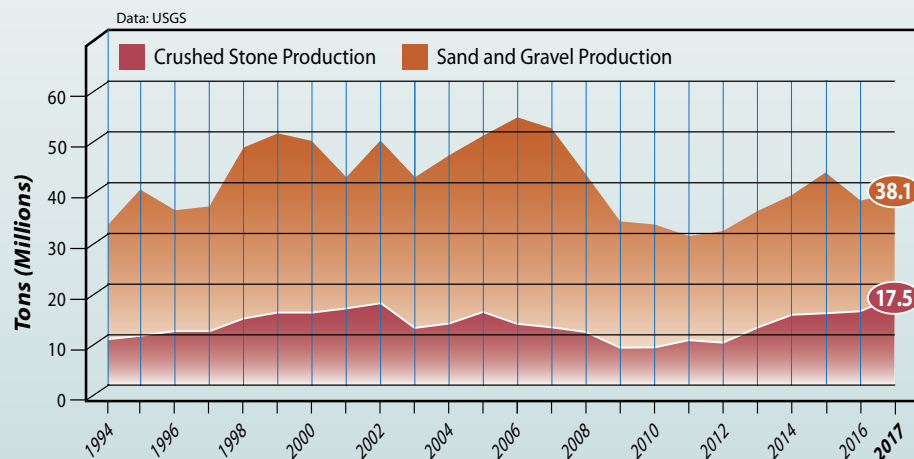


Figure 24. Aggregate production in Colorado, 1994–2017.

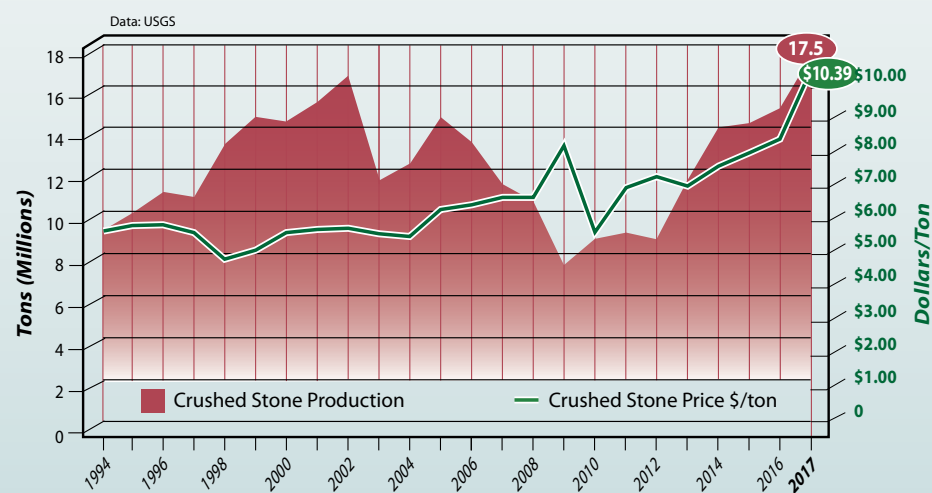
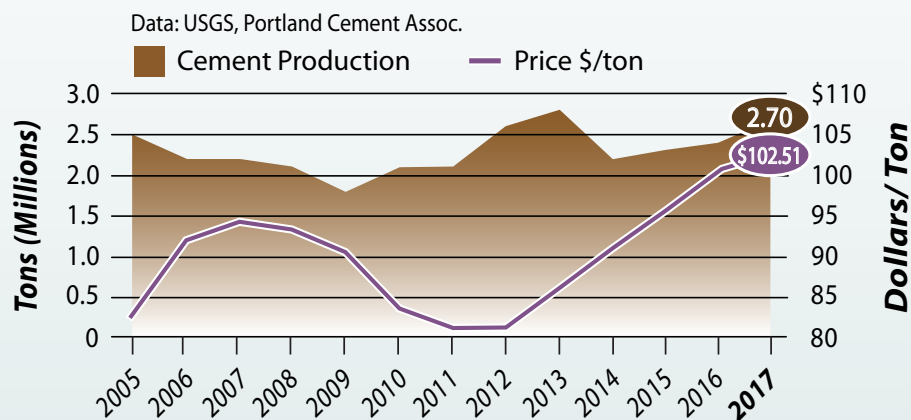


Figure 26. Price and production of crushed stone aggregate in Colorado, 1994–2017.

## 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. Three Portland cement plants operated in Colorado during 2017: LafargeHolcim (US), Inc. (Holcim) in Florence, the GCC of America plant in Pueblo, and the 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 2017 was 2.7 million tons. Production and average cement prices are shown on **Figure 27**.

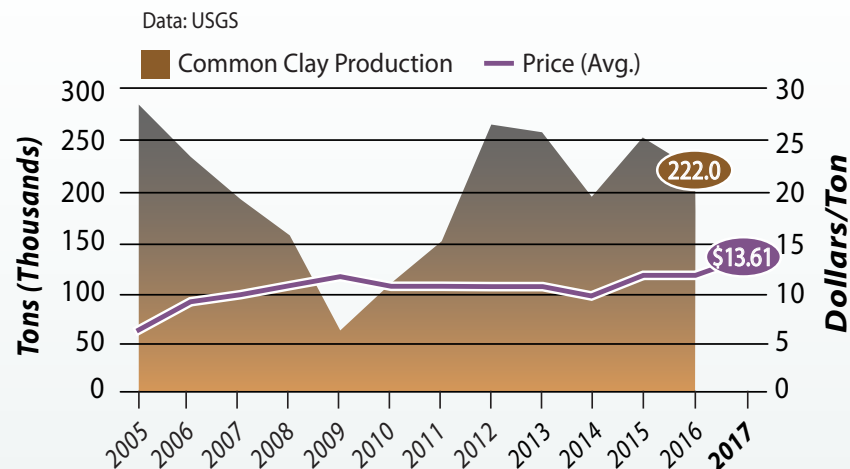


**Figure 27. Price and production of cement in Colorado, 2005–2017.**

## Clay and Shale

Common clay is mined primarily in eastern Colorado along the Front Range and is used mostly to make bricks and tiles. Clay has been mined from the Laramie Formation, Dawson Arkose, and Denver Formation as well as the Dakota Group. In 2017, DRMS records indicate that there were 45 active permits for general clay. Three brick companies currently operate in the Denver area: Acme Brick Co., Robinson Brick Co. (owned by General Shale/Wienerberger), and Summit Brick Co. Preliminary common clay and shale production was estimated at 251,000 tons in 2015 and 222,000 tons in 2016. The estimated

average price of common clay and shale was approximately \$13.61 per ton in 2017. The value of 2016 clay and shale production is estimated at \$2.6 million. Published production estimates for clay and shale were unavailable in 2017. As with other construction material, clay production has increased substantially since the recession of 2007-2009 (**Figure 28**).



**Figure 28. Estimated production and average price of common clay in Colorado, 2005–2017.**

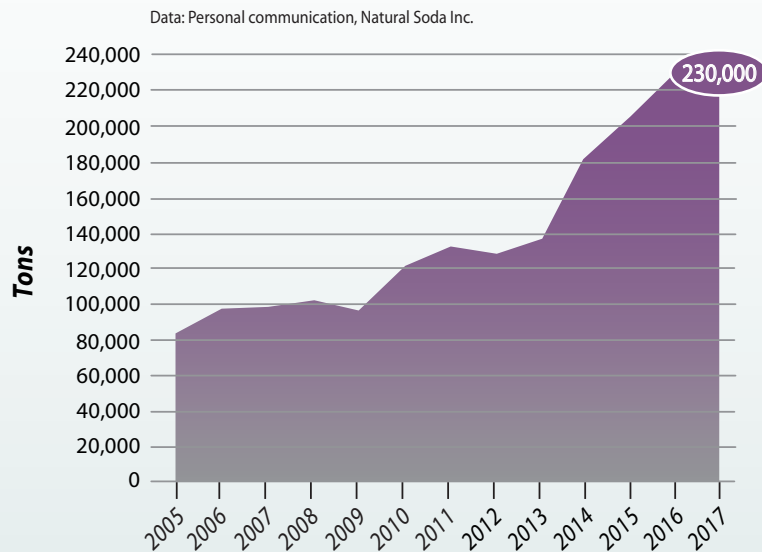
## Gypsum

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. Production information from the USGS for Colorado gypsum manufacturers is not available due to proprietary reasons. In 2017, Colorado was ranked 6th in the U.S. for production of gypsum and was one of the top six states accounting for 66% of the total U.S. 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 by Pete Lien & Sons for the cement industry and soil amendment from the Munroe Quarry north of Fort Collins in Larimer County.

## Sodium Bicarbonate (Nahcolite)

Sodium bicarbonate (more commonly known as baking soda) is primarily used in food preparation and baking, personal care products, pharmaceuticals, animal feed products, pool and water treatment, and other industrial applications. Natural Soda, Inc., owned by Enirgi Group Corporation (recently named Rincon

Ltd.), operates a nahcolite solution mine in Rio Blanco County and is the second largest producer of sodium bicarbonate in North America. Nahcolite is the naturally occurring mineral of sodium bicarbonate ( $\text{NaHCO}_3$ ). High grade nahcolite (>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 grades. Natural Soda completed an expansion project in 2013 to double the mine's production capacity to 250,000 tons per year. Estimated production in 2017 was between 230,000 and 240,000 tons (**Figure 29**).



**Figure 29. Sodium bicarbonate (nahcolite) production in Colorado, 2005–2017.**

### Silica

Sandstone 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. Production information of industrial sand in Colorado was withheld by the USGS to avoid disclosing proprietary data. In 2017, about 63% of the U.S. production was used in hydraulic fracturing operations and well packing and cementing sand. In 2017, the average national price for industrial silica sand and gravel reported by the USGS was \$30 per ton. Depending on the application and other factors, prices are highly variable.

Hydraulic fracturing sand (also called “frac” or “proppant” sand) is used in the hydraulic fracturing process to prop open rock fractures and facilitate the flow of oil and gas to wells. Prices for hydraulic fracturing sand are highly dependent on transportation costs. Most proppant sand is mined in the Midwest and Southern states. The CGS initiated a field reconnaissance evaluation of surficial eolian sand and sandstone formations throughout Colorado for their potential suitability as proppant sand. The results from samples collected during this project were published in 2018 report entitled “Reconnaissance of Potential Sand Sources in Colorado for Hydraulic Fracturing” and is available for free download at the CGS online bookstore (<https://store.coloradogeologicalsurvey.org/>). An online map viewer summarizing the results of this study is available at:

<https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html?id=d02eb2fde47543d78d4f74c536c8e3e4>

### 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 Fremont and Larimer counties for cement production. 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, etc. According to data provided by the USGS, quicklime sold for an average of about \$111 per ton nationally in 2017.

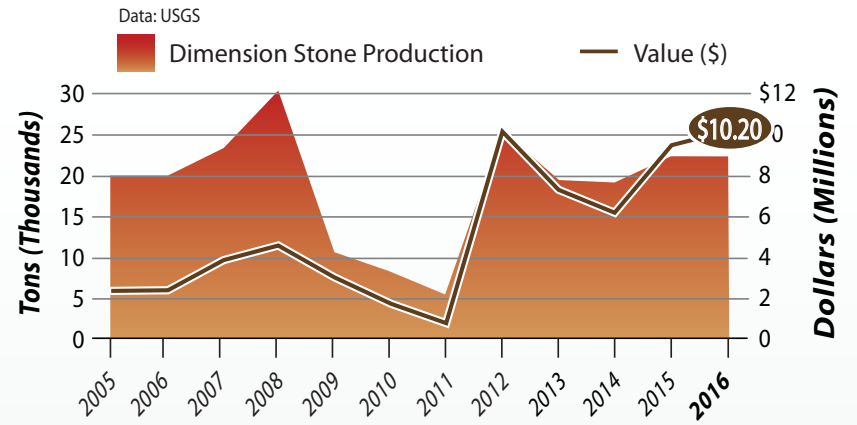
### Dimension and Decorative Stone

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 30** shows Colorado dimension stone production for the period from 2005-2016 based on USGS data. According to USGS estimates, Colorado produced about 22,388 tons of dimension stone in 2015 and again in 2016. Colorado data for 2017 were unavailable at the time of this report. In 2016, 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 2016 by descending value included limestone, granite, sandstone, miscellaneous stone, marble, and slate.



*Lyons Sandstone awaits use as dimension stone at Loukonen Bros. stockpiles.*

The Yule Marble quarry, located near the town of Marble, is currently operated by Colorado Stone Quarries Inc. and continues to produce marble. In the past, marble from the quarry was used for the construction of several important monuments including the Lincoln Memorial, the George Washington Monument, and the Tomb of the Unknown Soldier.

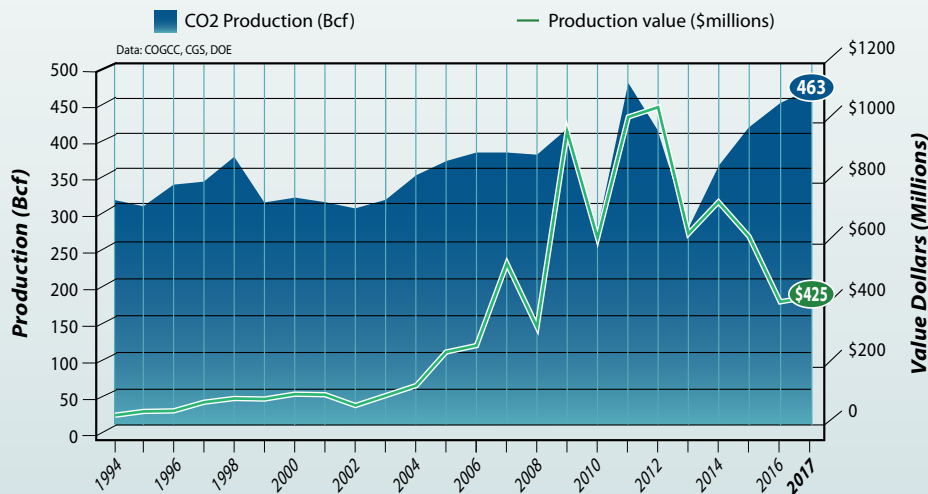


**Figure 30. Production and product value of dimension stone in Colorado, 2005–2016.**

# INDUSTRIAL GASES (NON ENERGY)

## Carbon Dioxide

Naturally occurring carbon dioxide gas (CO<sub>2</sub>) was produced in 2017 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 CO<sub>2</sub> in the past. Kinder Morgan's McElmo Dome and Doe Canyon Deep units are the largest producers in Colorado. CO<sub>2</sub> is produced from wells in a similar way to natural gas production. The CO<sub>2</sub> 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). CO<sub>2</sub> is used to extend the life of a well after the initial pressure in the well decreases. Other uses for CO<sub>2</sub> include welding gases, manufacture of dry ice, and in the food and beverage industry. In 2017, Colorado produced an estimated 463 billion cubic feet (Bcf) at an estimated average price of \$0.92 per million cubic feet (Mcf) for an estimated value of \$425 million. **Figure 31** shows Colorado's estimated CO<sub>2</sub> production for the period 1994-2017.



**Figure 31. CO<sub>2</sub> production and estimated production value in Colorado, 1994–2017.**

## 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, has reportedly agreed with a local producer to install a 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 2017 was about \$200 per Mcf.

## Acknowledgements

The authors would like to thank our colleagues at the CGS and other state organizations who provided data and expertise that assisted with the research associated with this document. Larry Scott, with the CGS, produced the graphics, maps, and the layout of the publication. We would like to also thank Matt Morgan, at the CGS, and James Cappa for their technical reviews. Production, price, and production value estimates reported here are subject to change. This project was funded through state severance tax funds.

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Couer Mining	<a href="https://www.coeur.com/">https://www.coeur.com/</a>
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