

INFORMATION SERIES 79

# Colorado Mineral and Energy Industry Activities 2015-2016

by James A. Cappa, Michael K. O'Keeffe, James R. Guilinger and Karen A. Berry





# Colorado Mineral and Energy Industry Activities in 2015-2016

by James A. Gappa<sup>1</sup>, Michael K. O'Keeffe<sup>2</sup>, James R. Guilinger<sup>1</sup> and Karen A. Berry<sup>2</sup>

<sup>1</sup> Consulting geologist <sup>2</sup> Colorado Geological Survey



Dr. Ramona M. Graves  
DEAN,  
COLLEGE OF EARTH  
RESOURCE SCIENCES  
& ENGINEERING



Karen A. Berry  
STATE GEOLOGIST

Cover:

Blue Sky gas field in Sand Wash Basin, Moffat County by Larry Scott.

# TABLE OF CONTENTS

<b>TABLE OF CONTENTS</b>	<b>iii</b>	<b>NONFUEL MINERAL RESOURCES</b>	<b>19</b>
<b>ECONOMIC SUMMARY</b>	<b>1</b>	4.0 Nonfuel Mineral Resources	19
Severence Tax Revenue	2	4.1 Metal Mining	19
State Land Board Mineral Revenue	4	4.1.1 Molbdenum	19
Federal Mineral Lease and Royalty Revenue	4	4.1.2 Gold and Silver	20
<b>CONVENTIONAL ENERGY RESOURCES: OIL AND GAS</b>	<b>5</b>	4.1.3 Metal Exploration and Development Activities	22
Summary	5	<b>INDUSTRIAL MINERALS AND CONSTRUCTION MATERIALS</b>	<b>23</b>
1.1 Oil	5	4.2.1 Agggregate - Sand, Gravel, and Crushed Stone	23
1.2 Natural Gas	8	4.2.2 Cement	24
1.3 Assessment of Mancos Shale Oil and Gas Potential in the Piceance Basin	8	4.2.3 Clay and Shale	25
1.4 Coalbed Methane	9	4.2.4 Gypsum	26
1.5 County Rankings - Oil and Natural Gas Production	9	4.2.5 Sodium Bicarbonate (Nahcolite)	26
1.6 Drilling Permits	11	4.2.6 Silica	26
1.7 Oil Shale	11	4.2.7 Limestone, Calcium Carbonate, and Lime	26
<b>CONVENTIONAL ENERGY RESOURCES: COAL</b>	<b>13</b>	4.2.8 Dimension Stone and Decorative Stone	27
2.0 Coal	13	4.2.9 Peat	28
<b>CONVENTIONAL ENERGY RESOURCES: URANIUM</b>	<b>17</b>	4.2.10 Gem and Specimen Minerals	28
3.0 Uranium	17	<b>INDUSTRIAL GASES (NON-ENERGY)</b>	<b>29</b>
3.1 Uranium Exploration and Development in Colorado	18	4.3.1 Carbon Dioxide	29
		4.3.2 Helium	29
		<b>INFORMATION SOURCES and ACKNOWLEDGEMENTS</b>	<b>31</b>



# ECONOMIC SUMMARY

The total value of mineral and energy fuels production in Colorado for 2015 is estimated to be \$13.43 billion, a 29% decline from the \$18.8 billion production value in 2014. The mineral production value for 2015 is separated into commodity types in **Figure ES-1**. Mineral and energy production values for 1995 through 2015 are shown in **Figure ES-2** which depicts a large increase until 2014 and a diminished value in 2015.

Oil and natural gas production accounted for 70% of the total mineral and energy production value in Colorado in 2015 and accordingly, these commodities are the dominant factors in the overall mineral and energy value of Colorado. Oil and natural gas producers in Colorado had six years of improved rates of production due to the utilization of horizontal drilling and hydraulic fracturing (fracing) technologies which helped lead to an oversupply, especially for oil, and the attendant unprecedented declines in the price for oil and natural gas.

According to the U.S. Department of Energy, Energy Information Agency (EIA), Colorado has the eighth largest proven oil reserves in the U.S., and the seventh largest reserves of natural gas. The total estimated value of oil and natural gas production in 2015 is \$9.51 billion, a decline of 36% from the 2014

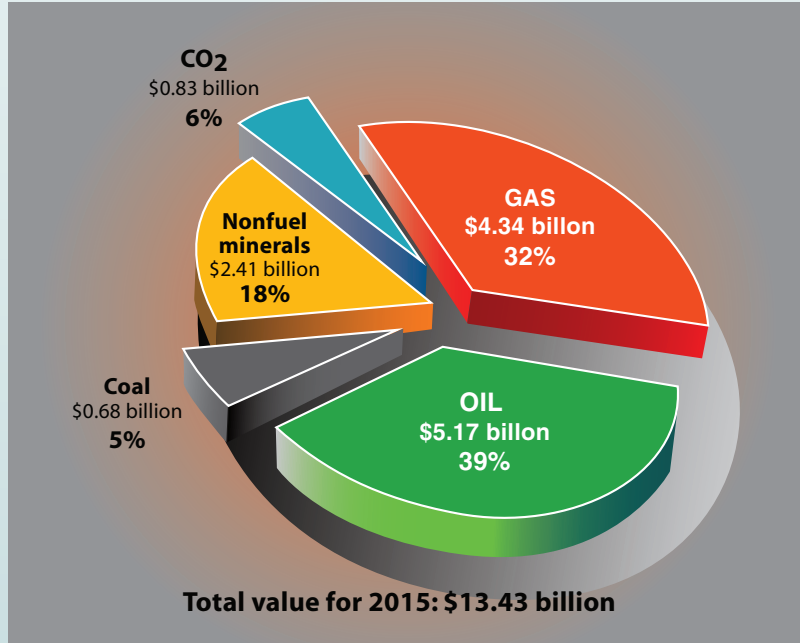


Figure ES-1. Colorado mineral production value by commodity.

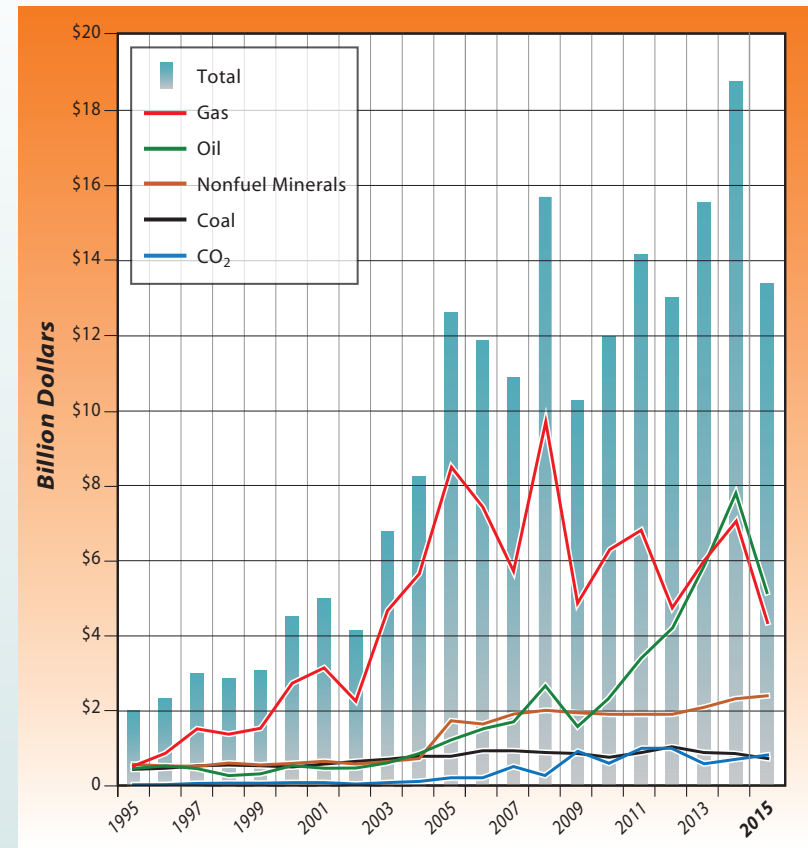


Figure ES-2. Mineral and energy fuel production value in Colorado, 1995–2015.

value of \$14.83 billion. The significant production increases up to 2014 are largely due to the utilization of horizontal drilling and hydraulic fracturing techniques for oil and natural gas in the Niobrara Formation, largely in Weld County.

Colorado is the 11th largest coal producer in the U.S., with both underground and surface mines currently in operation on the Western Slope. The estimated value of Colorado coal production in 2015 was \$677 million, down 22% from the 2014 value of \$867 million. The reduction in coal mine production is due primarily to the nationwide trend away from coal-fired power plant energy, and increased use of natural gas and renewable energy. Nonetheless, coal is still the largest source of reliable, low-cost electricity in Colorado and nationally.

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 2015 is \$2.41 billion, about a 3.9% percent increase over the 2014 estimated value of \$2.32 billion. Increased production of crushed stone, cement, and sand and gravel aggregate accounted for the increase. With a 2015 production of 21,790 metric tons of molybdenum from two mines, Colorado is the largest molybdenum producer in the U.S. Although just one mine in the state publically reported gold production in 2015, Colorado remains the third largest producer of the metal in the U.S. as it was in 2014.

Carbon dioxide produced in Colorado is used primarily for enhanced oil recovery in the Permian Basin oil fields of Texas. The production value in 2015 was an estimated \$830 million, a 12.5% increase from the 2014 value of \$738 million.

There was no uranium mining in Colorado in 2015. Continued low uranium prices primarily account for the lack of mining in the state. Despite the low prices however, company consolidations and project development was ongoing in 2015 and continued into early 2016.

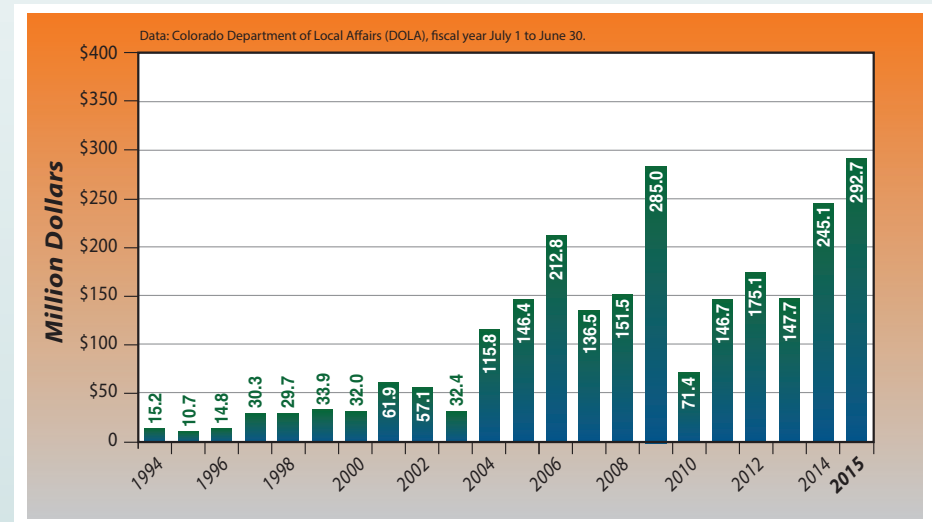
## SEVERANCE TAX REVENUE

Severance taxes are state taxes collected on the production of oil, gas, coal, molybdenum, and other metallic minerals. 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), including the Colorado Oil and Gas Conservation Commission (COGCC), the Division of Reclamation, Mining, and Safety (DRMS), the Colorado Water Conservation Board (CWCB), and the Colorado Parks and Wildlife (CPW). In fiscal year (FY)\* 2016 Colorado will have collected an estimated \$292.7 million in severance taxes, a increase of 19% from the \$245.1 million collected in FY 2015 (Colorado Department of Revenue data). The Colorado Department of Local Affairs (DOLA) administers the distribution of severance tax revenue to affected county and local governments. **Figure ES-3** shows the annual severance taxes collected since 1994. The map in **Figure ES-4** shows the distribution of FY 2015 severance taxes to each county.

\*The Colorado state fiscal year runs from July 1 to June 30 of the following year.

A recent Colorado Supreme Court decision has significant impacts on the collection and distribution of severance tax. As a result of the April 2016 decision in *BP America v. Colorado Department of Revenue*, taxpayers are allowed to take a tax deduction for the capital costs associated with natural gas transportation and processing facilities. Under the statute, any transportation, manufacturing and processing costs can be deducted from revenue for purposes of the state's severance tax, the court said. The legislature did not distinguish between different kinds of costs, so the costs of capital should qualify for the deduction, the court said.

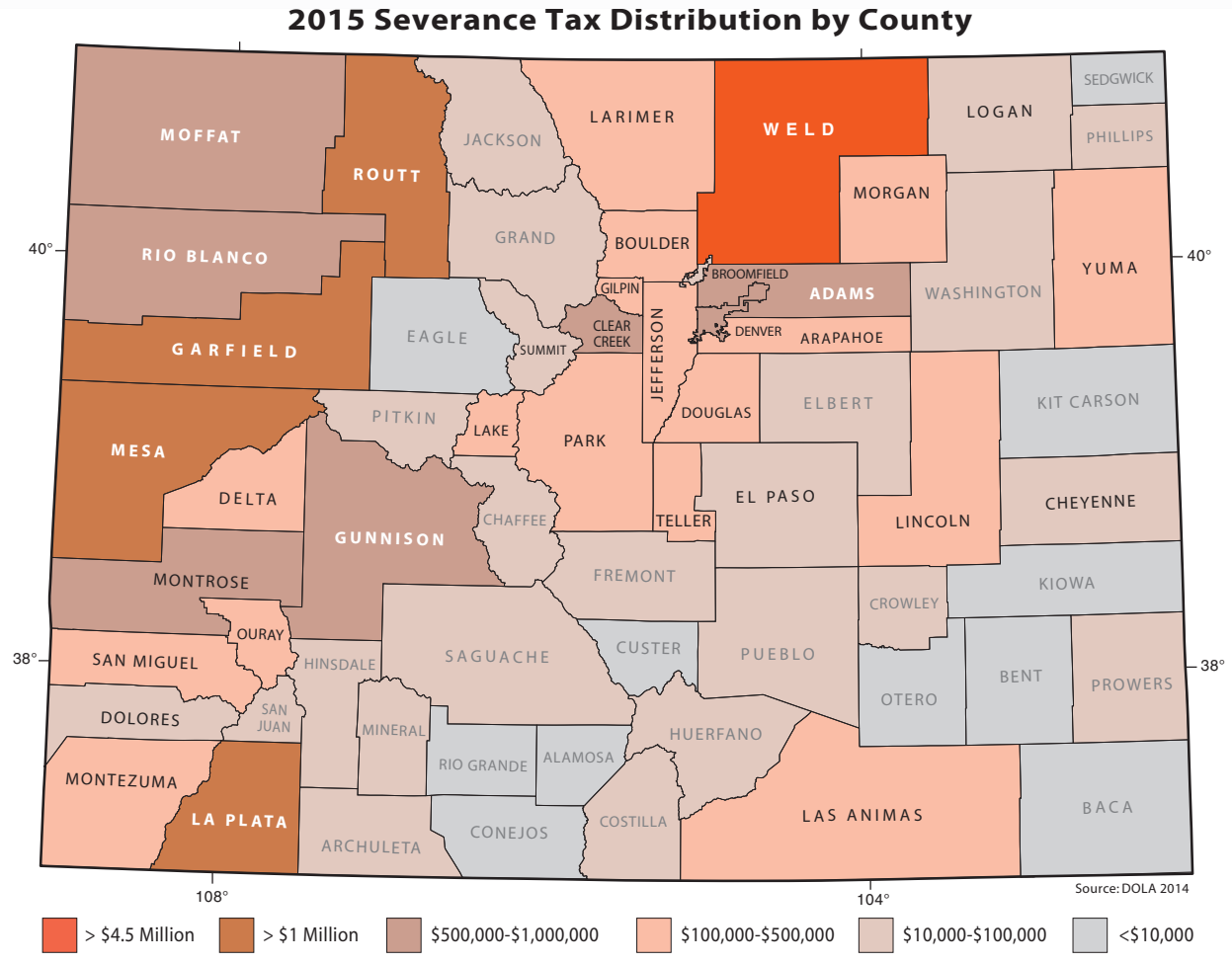
According to the Office of State Planning and Budgeting, FY 2015-16 severance tax refunds related to the court ruling are estimated at \$17.8 million. Senate Bill 16-218 placed a restriction on \$77.4 million on severance tax money allocated to DNR and DOLA, preventing the money from being expended in case the money is needed to help cover the refunds. In August 2016, the Joint Budget Committee voted to release \$19.9 million of the amount to DOLA. As of November 2016, \$57.5 million remains restricted pursuant to S.B. 16-218.



**Figure ES-3. Colorado mineral severance tax revenues 1994–2015.**



Figure ES-4. Colorado mineral severance tax distribution by county, fiscal year 2014-2015.



The Suncor refining complex in Commerce City, Adams County. Photo Larry Scott

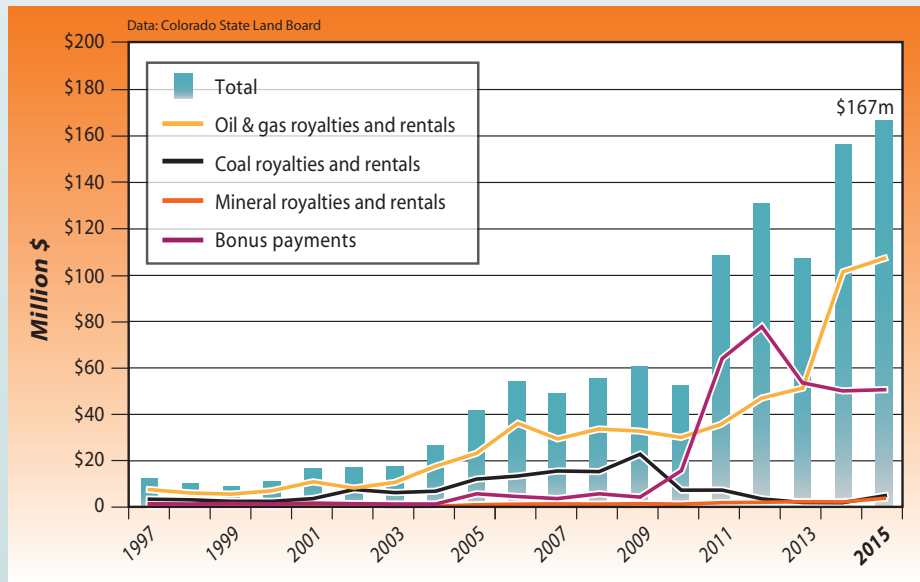


## STATE LAND BOARD MINERAL REVENUE

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 FY 2015, the SLB received a record high \$167.0 million, an increase of 7% from the FY 2014 value of \$155.9 million. The revenues consisted of the following: oil and natural gas royalties and rentals, \$107.3 million; coal royalties and rentals, \$5.0 million; mineral royalties and rentals, \$4.0 million; and bonuses, \$50.7 million. **Figure ES-5** shows the State Land Board revenues from FY 1997 to FY 2015.

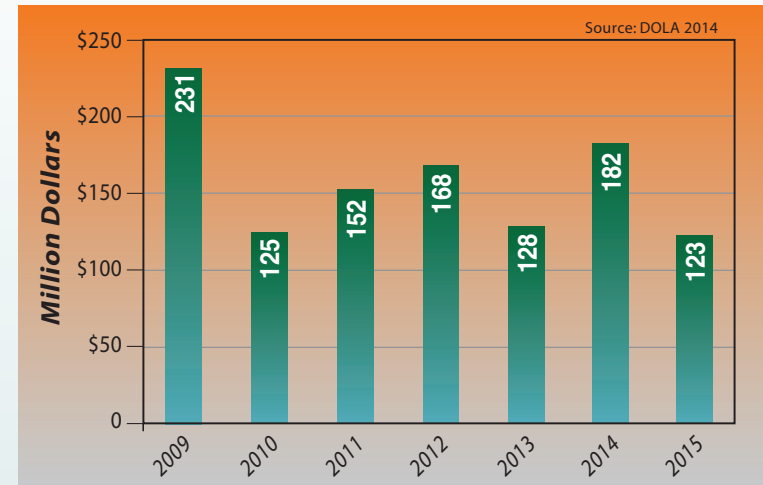
## FEDERAL MINERAL LEASE AND ROYALTY REVENUE

Lands owned by the federal government constitute 36.2% 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. The DOLA distributes these funds to local governments affected by mineral and energy development and the CWCB. In FY 2015, mineral lease revenues totaled approximately \$123 million, a decline of 32% from the \$182 million received in FY2014.



**Figure ES-5. Colorado State Land Board mineral revenues, 1997–2015.**

**Figure ES-6** shows Colorado's share of federal mineral lease revenues from 2009 to 2015.



**Figure ES-6. Colorado revenue from federal mineral leases 2009–2015.**

# CONVENTIONAL ENERGY RESOURCES: OIL AND GAS

## SUMMARY

After six years of steady growth, the value of Colorado oil and natural gas production declined 36% from an estimated all-time high of \$14.8 billion in 2014 to an estimated \$9.51 billion in 2015. Strong increases of both oil and natural gas production were not enough to offset the sharp decline in the market prices for both oil and natural gas.

Declining prices have had an effect upon Colorado oil and natural gas businesses. Encana Corp., a major producer in the oil and natural gas business with headquarters in Denver, cut an additional 20% of its staff in 2016. This after Encana had a 20% staff reduction in 2015. Encana also announced a \$900 million deal to sell all of its assets in the highly productive Denver-Julesburg (DJ) Basin to a newly formed Denver company, Crestone Peak Resources. Bill Barrett Corp., another important Colorado producer, announced a cut of “less than 20%” of its staff this year ([http://www.bizjournals.com/denver/blog/earth\\_to\\_power/2016/02/oil-and-gas-job-losses-continue-to-hit-colorado.html](http://www.bizjournals.com/denver/blog/earth_to_power/2016/02/oil-and-gas-job-losses-continue-to-hit-colorado.html)). Anadarko Petroleum Corp., Colorado’s largest oil producer, announced in March 2016 that it would cut about 1,000 jobs, or roughly 17% of its workforce. Anadarko will still keep a strong effort in the DJ Basin, according to a company spokesperson ([http://www.bizjournals.com/denver/blog/earth\\_to\\_power/2016/03/anadarko-petroleum-to-lay-off-big-chunk-of-its.html](http://www.bizjournals.com/denver/blog/earth_to_power/2016/03/anadarko-petroleum-to-lay-off-big-chunk-of-its.html)). Noble Energy, the second largest oil producer in Colorado, announced layoffs of 170 employees in 2015 (<http://www.denverpost.com/2015/12/31/energy-oil-price-collapse-weighs-heavy-on-colorado-economy/>).

Most of the drilling activity and production increases are in “unconventional reservoirs”, especially in the DJ Basin of northeastern Colorado where the Late Cretaceous age Niobrara Formation has become a prolific producer of “tight” (tight in oilfield parlance refers to rocks such as shale which have low porosity and permeability) shale oil and natural gas. The introduction of improved hydraulic fracturing and horizontal drilling techniques has allowed these unconventional reservoirs to be produced at a relatively low cost. Other unconventional reservoir areas of the state, especially the Piceance Basin, have also experienced increased exploration activity and production. The map in **Figure 1-1** shows the major sedimentary basins in Colorado and the location of recent oil and natural gas drilling permits.

Conventionally produced oil and natural gas production (e.g., vertical wells, permeable sandstone or carbonate reservoirs and wells that do not require hydraulic-fracture stimulation) continued its downward decline through 2014 and 2015. Some conventional oil fields such as the Rangely field in the northern

Piceance Basin, benefitted from hydraulic fracturing and horizontal drilling in the Niobrara Formation.

## 1.1 OIL

Colorado’s oil production reached an all-time high of 40 million barrels of oil (BO) in 1977 and declined to approximately 30 million BO for a number of years until 1995 when it declined again to between 19.3 and 25 million BO. In 2008-2009, a rapid rise in production began due to higher oil prices and the utilization of hydraulic fracturing and horizontal drilling techniques. Crude oil production in Colorado during 2015 rose to a remarkable 127.6 million barrels of oil (MMBO) from 94.6 MMBO in 2014, a 35% increase (**Figure 1-2**). This increased annual production of 33 MMBO over the course of one year is greater than Colorado’s individual annual oil production in the period from 1978 to 2011. The production increase in Colorado and other oil producing states, plus efforts by the Organization of Petroleum Exporting Countries (OPEC) to retain market share by lowering the price of a BO, resulted in an oversupply of oil in the market and a corresponding decline in the price for a barrel of oil (**Figure 1-3**).

Variations in the price of oil are a principal variable factor in the cost of energy resources, especially gasoline, in Colorado and in the U.S. Oil prices have changed dramatically over time:

- In 1973, oil prices had been fairly stable for a couple of decades at approximately \$20 per barrel.
- The OPEC oil embargo in 1974 led to long lines at gasoline stations across the county and the price rose to \$115.62 per BO by April of 1980.
- Disintegration of the OPEC monopoly and other factors led to a very low price of \$16.44 per BO by November 1998.
- Prices increased over the next decade to an all-time high of \$133.86 per BO in July 2008.
- The Great Recession intervened and prices dropped quickly to \$46.86 per BO in January 2009.
- Oil prices rose to \$103.99 per barrel in May 2014 as the U.S. economy improved.
- Starting in about 2009, improvements in production technologies, mainly hydraulic fracturing and horizontal drilling, resulted in production increases and price reductions from OPEC which led to an over supply of oil and a corresponding decline in oil prices to \$48.76 per BO in June 2016.

# Oil & Gas Well Drilling Permits in Colorado

Nov 2014 - Dec 2015

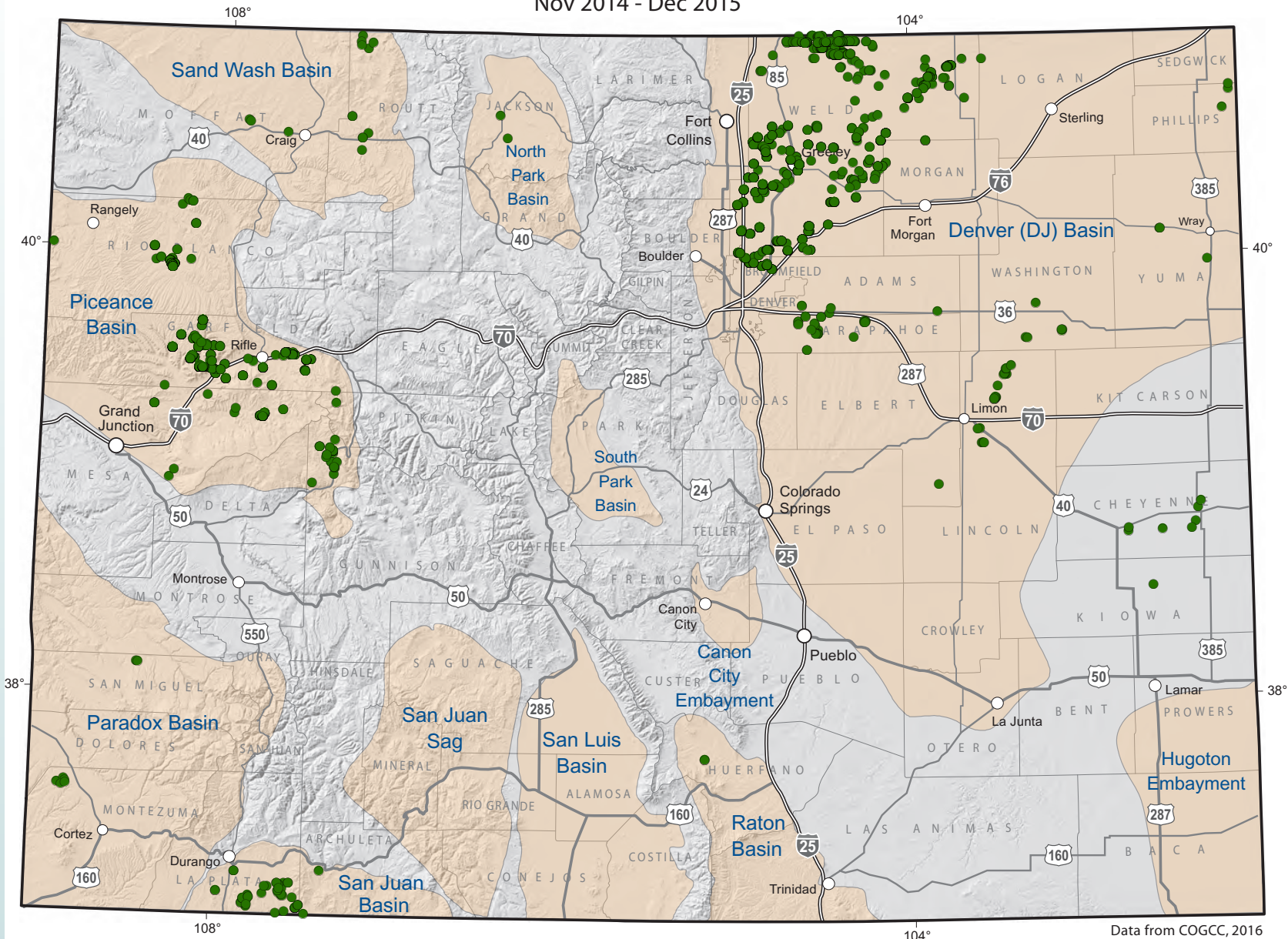


Figure 1-1. Map showing Colorado's sedimentary basins and the location of oil and gas well drilling permits from November 2014 to December 2015.

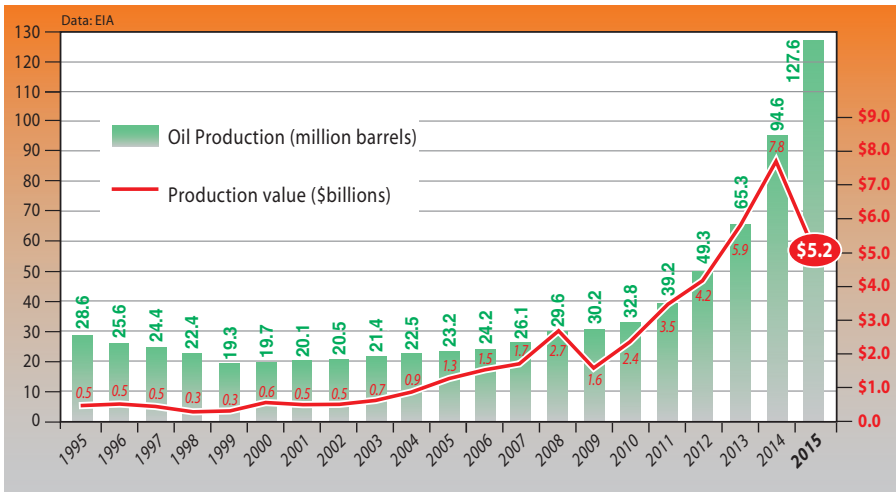


Figure 1-2. Oil production and production value in Colorado, 1995–2015.

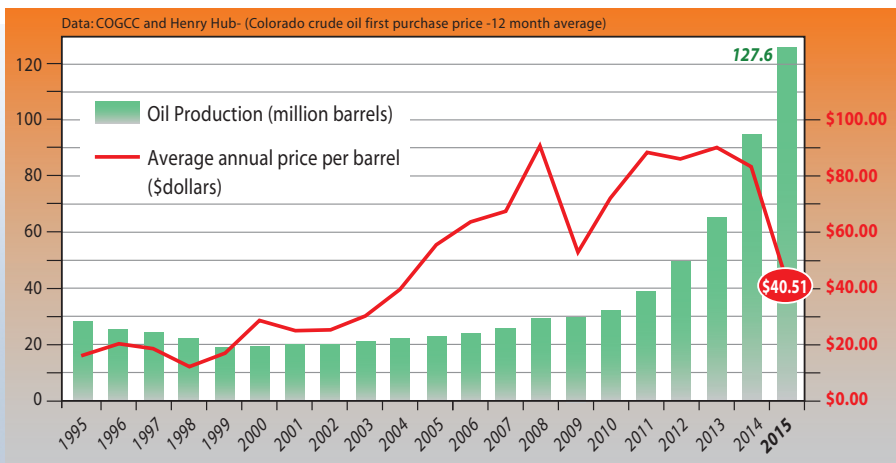


Figure 1-3. Colorado oil production and average annual price per barrel, 1995–2015.

The overall oil production value in 2015 for Colorado was \$5.2 billion, a 33% decline from the 2014 production value of \$7.8 billion. As of 2014, Colorado ranked eighth among the top ten states with proven oil reserves of 1.451 billion BO, more than twice the 2013 reserves of 0.618 billion BO (Figure 1-4).

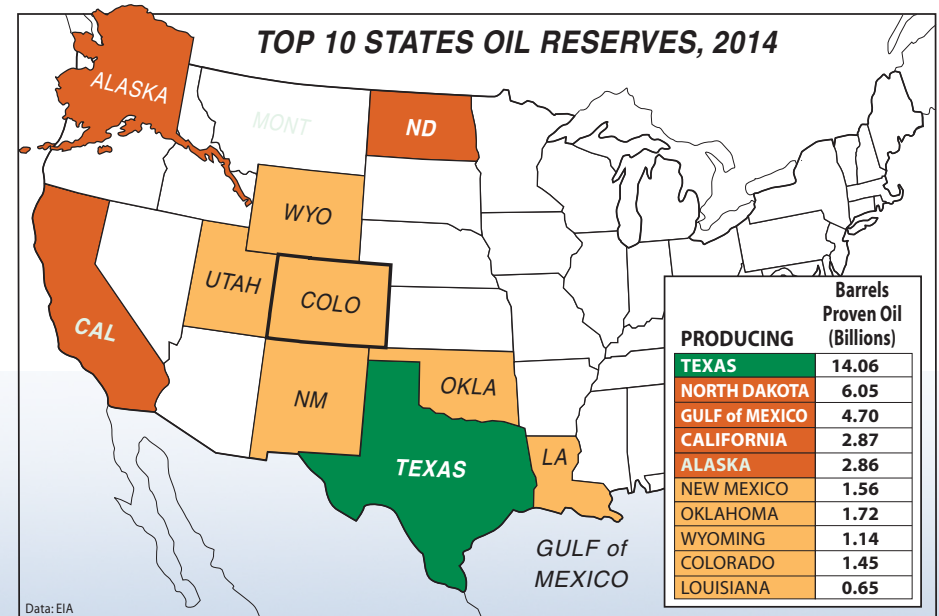


Figure 1-4. Top 10 states with proven oil reserves in 2014.



## 1.2 NATURAL GAS

Natural gas production was fairly stable from 1975, at approximately 200 billion cubic feet (Bcf), to 1988 when it started a sustained rise. During 2015, estimated natural gas production in Colorado rose slightly to 1,709 Bcf, a 4.7% increase from the 2014 value of 1,631 Bcf. Henry Hub prices (a regional standard for natural gas pricing) for natural gas declined from almost \$9 per thousand cubic feet (Mcf) in 2008 to an approximate range of \$3 to \$4.50 between 2009 and 2014. The 2015 average spot price was \$2.54 per Mcf, a decline of 42% from the 2014 price of \$4.39 per Mcf (**Figure 1-5**). The overall production value for Colorado natural gas in 2015 was \$4.34 billion, a decline of 39% from the 2014 value of \$7.16 billion. As with oil, the main factor of the decreasing value of natural gas is the market price. In 2014, Colorado had proven natural gas resources of 21,992 Bcf which is the seventh largest in the U.S. (**Figure 1-6**).

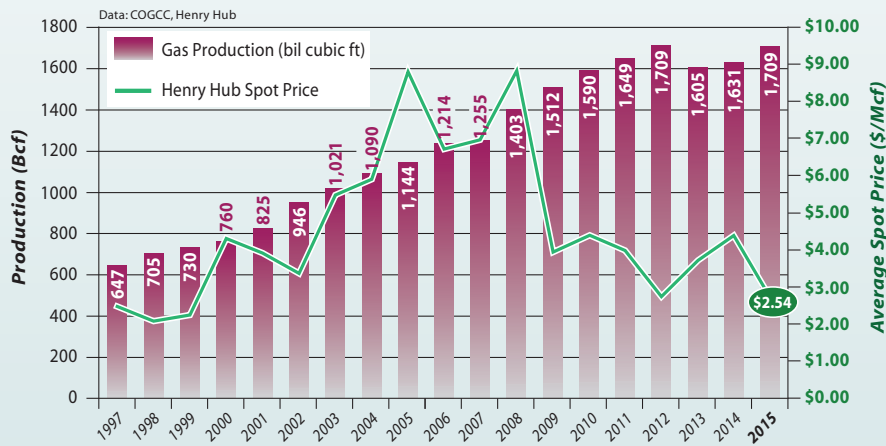


Figure 1-5. Colorado natural gas production and average spot price, 1997-2015.

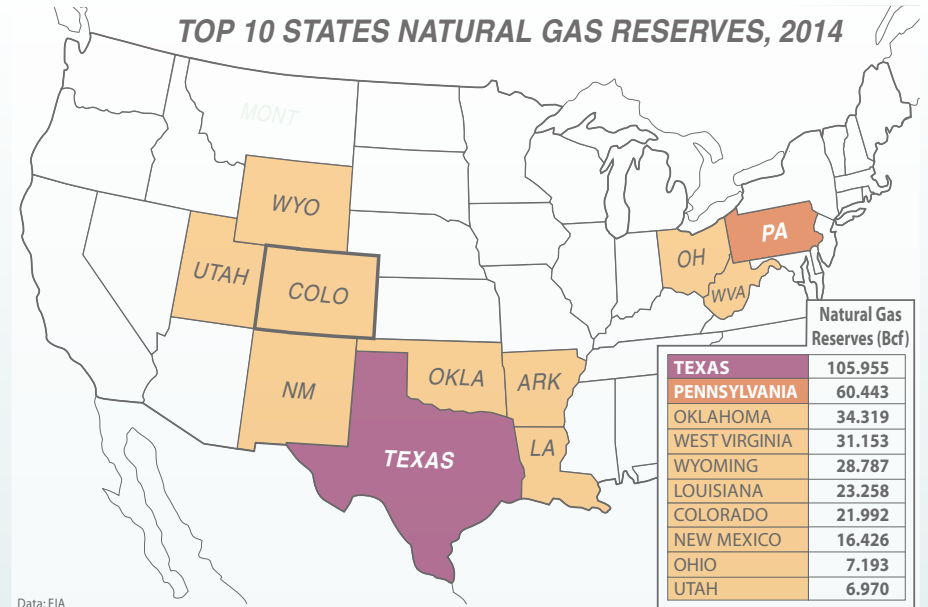


Figure 1-6. Top 10 states with proven natural gas reserves in 2014.

## 1.3 ASSESSMENT OF MANCOS SHALE OIL AND GAS POTENTIAL IN THE PICEANCE BASIN

In July 2016, the USGS released the results of a multiyear oil and gas assessment of the Mancos Shale in the Piceance Basin of 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. A previous assessment was conducted in 2003 and that report estimated 1.6 Tcf of natural gas resources were located in the Piceance Basin. Since 2003, over 2,000 drill holes for oil and natural gas have been completed in the basin allowing a new and significantly larger resource estimate. The resources are classified as continuous unconventional (tight) resources that would be best developed by a combination of vertical and horizontal drill holes and utilization of hydraulic fracturing technology to recover the oil and gas from the Mancos Shale (US Geological Survey Fact Sheet 2016-3030).



- Weld County remains the single largest producer with a total value of over \$6.09 billion, a 23% decline from the 2014 value of \$7.94 billion.
- Garfield County remains in the second tier with a total combined value of \$1.48 billion, a 43% decline from the 2014 value of \$2.61 billion.
- La Plata, Las Animas, and Rio Blanco counties make up the third tier of production value, with a total value of \$1.34 billion, a decline of 37 % from the 2014 value of \$2.14 billion.

The total 2015 estimated production value for Colorado was \$9.51 billion, a 36% decline from the 2014 estimated production value of \$14.8 billion. **Figure 1-9** shows the oil production by county for 2015. Weld County was the state's largest producer of oil in 2015 with 114,313,274 BO. Rio Blanco County placed second with 4,407,190 BO, and Garfield County placed third with 1,745,747 BO. **Figure 1-10** shows the 2015 natural gas production by county. Weld County was the largest natural gas producer in 2015 with 573,235,854 Mcf, Garfield County was second with 556,153,761 Mcf, and La Plata County was third with 322,630,962 Mcf.

Figure 1-9. Total oil production by county in Colorado, 2015.

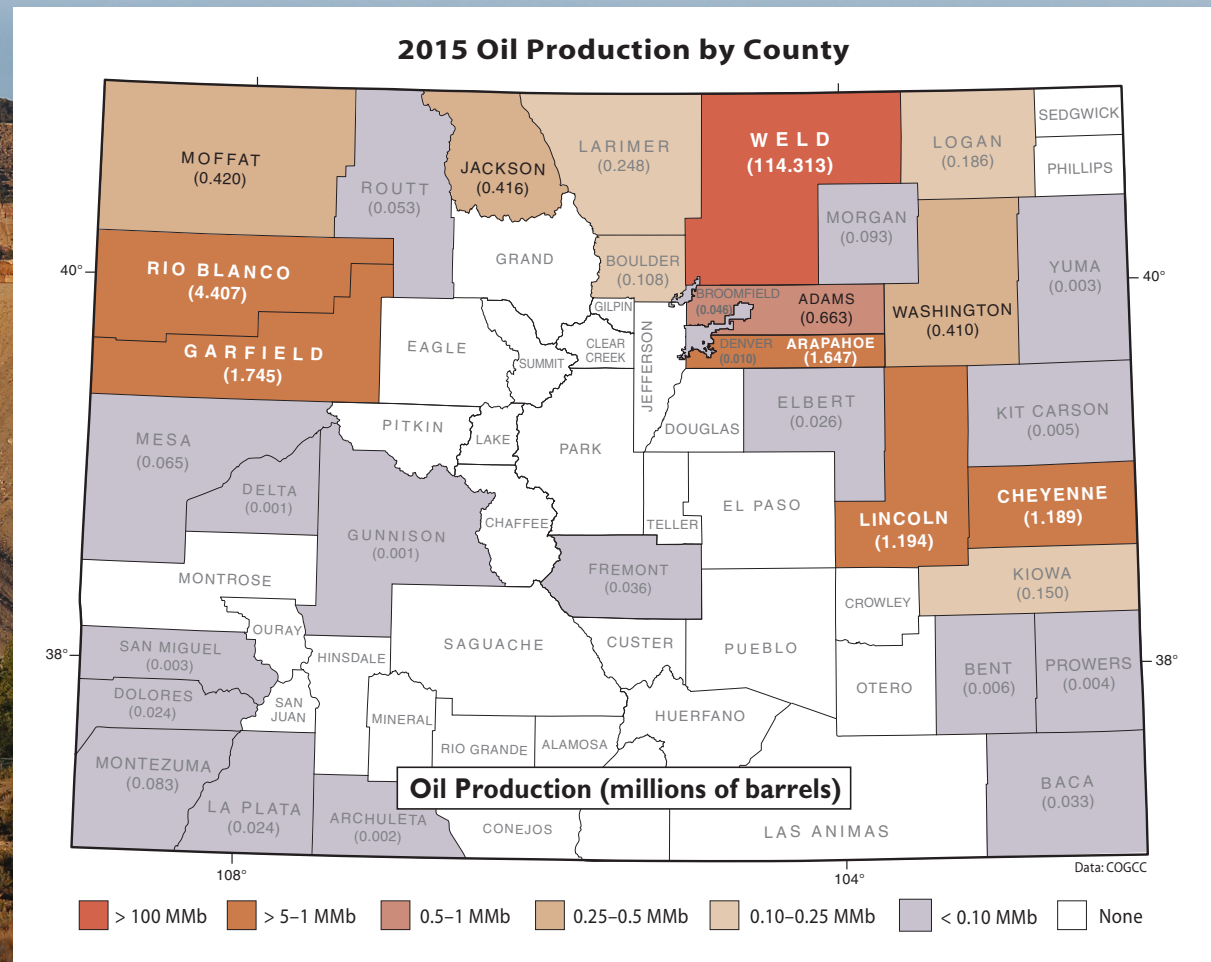
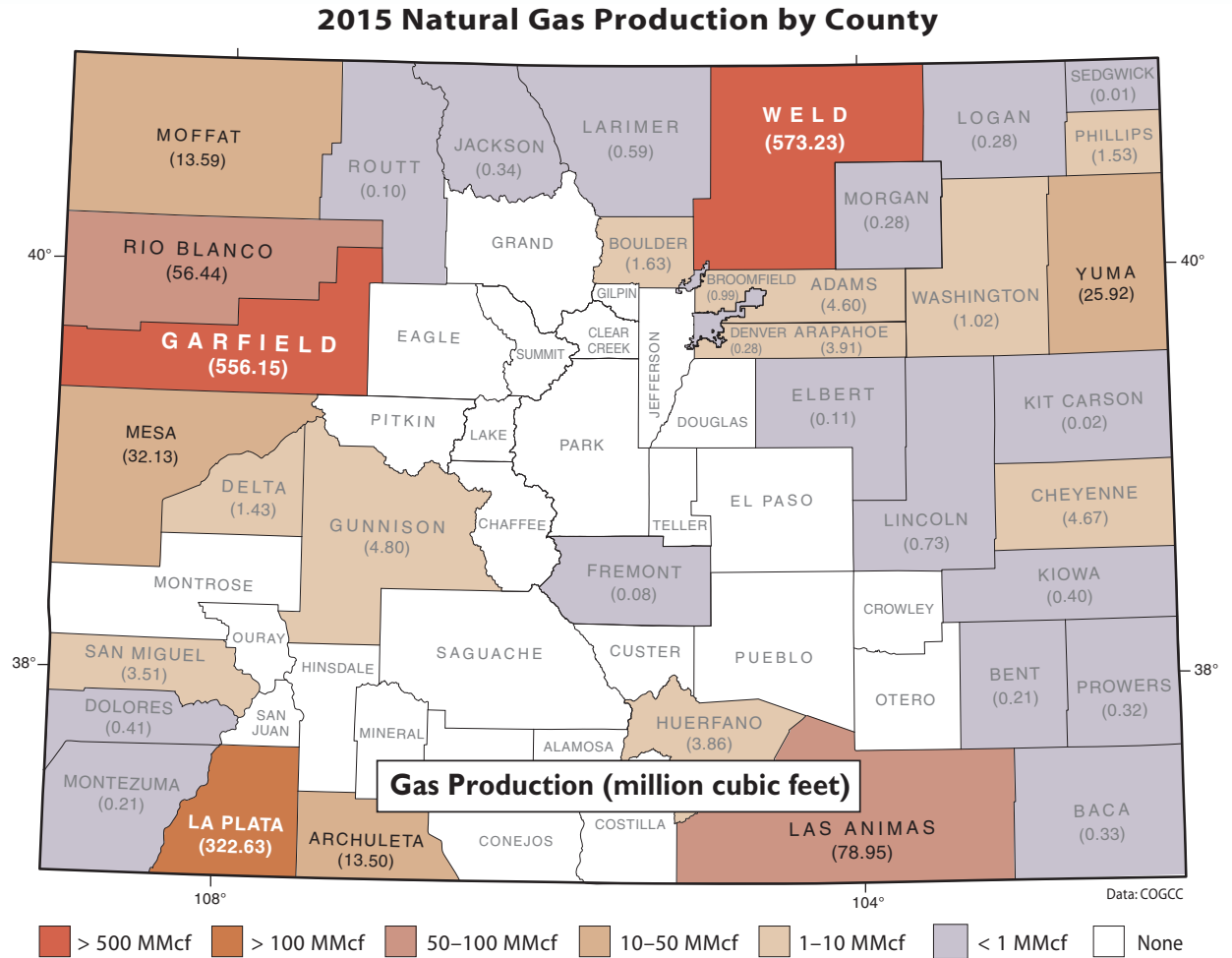


Photo: Mike O'Keefe



Figure 1-10. Total natural gas production by county in Colorado, 2015.



### 1.6 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. COGCC data indicate 2,987 drilling permits were approved in 2015, a decline of 29% from the 4,190 approved in 2014. However, 1,297 permits were approved from January to June, 2016, suggesting that the 2016 approved permits will be similar to 2015 (COGCC).

Well spud notices are required when operators start to drill a well. In 2015, 1,450 well spud notices were received by COGCC, a decline of 55% from the 2,248 notices in 2014. From January to June of 2016, only 387 well spud notices were received by COGCC, a strong indicator of the dramatic decline in oil and

natural gas drilling in Colorado. Figure 1-11 shows the number of annual oil and natural gas drilling permits in Colorado from 1994 to 2015.

### 1.7 OIL SHALE

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. Estimated resources are 4.3 trillion BO, which can be recovered from solid bituminous material called kerogen. The Piceance Basin in Colorado contains an estimated 1.525 trillion BO with an estimated 920 billion BO in place at an oil yield of 15 gallon per ton (gpt) or greater and 352 billion BO at an oil yield of 25 gpt or greater (USGS Fact Sheet 2012-3145).

Oil shale is different from oil produced from shale reservoirs, which is currently being recovered by mostly unconventional drilling methods from the Cretaceous age Niobrara Formation in the DJ Basin of northeastern Colorado. Recovery of oil from oil shale is more difficult and expensive than oil from conventional or unconventional petroleum resources. In general, heat must be supplied to the kerogen layers to release the oil allowing the product to flow.

The Colorado office of the Bureau of Land Management awarded seven Oil Shale Research, Development, and Demonstration Leases during the period from 2005 to 2009. The following companies were awarded leases: Shell Frontier Oil and Gas, Inc., three leases; Chevron USA, one lease; ExxonMobil Exploration Co., one lease; America Shale Oil, LLC, one lease; and Natural Soda Holdings, Inc., one lease. In 2012 and 2013, Shell and Chevron discontinued oil research on their leases. In March 2016, ExxonMobil discontinued their

research program on their lease citing the current oil price as a factor in their decision.

American Shale Oil, LLC continues its in-situ research program using burners in a horizontal well. The company plans to fuel the burners by using natural gas co-produced with the oil. Recovery of the oil would be by a parallel recovery well. Natural Soda Holdings, Inc. in conjunction with Natural Soda, Inc. has successfully operated a sodium bicarbonate in-situ solution mine in the Piceance Basin. They plan to utilize their solution mining skills to develop a process to solution mine the oil shale beds. For more than a century, projects have been developed to mine these oil shale deposits; however, none of these projects has been economically successful. The resource is very large and tantalizing, but the challenge to economically mine these deposits is also great. Furthermore, the current low price for oil is a drag on continued development.

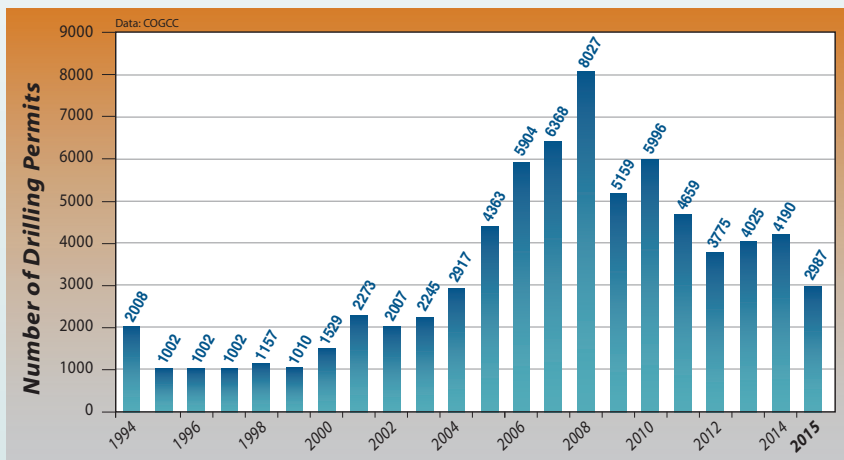


Figure 1-11. Annual oil and gas drilling permits in Colorado, 1994–2014.



Photo Larry Scott

# CONVENTIONAL ENERGY RESOURCES: COAL

## 2.0 COAL

Coal mining in Colorado continues to be a critical component of the state's electrical power supply chain. In 2014, 59% of Colorado's electricity was generated by coal-fired power plants, 22% came from natural gas-fired power plants, and 18% came from renewable energy sources, such as wind, hydroelectric, solar, and biomass. However, the EIA report for March 2016, on monthly electricity net generation for Colorado shows a changing distribution of electrical power sources. Coal still remains the leading source with 45%; natural gas has gone up to 28%, and renewables up to 27%. The decline of the use of coal for electricity generation is due to three main factors:

1. New greenhouse gas regulations, potential additional regulations, and taxes designed to cut carbon dioxide emissions have increased operating costs and investment risks for coal-fired power plants;
2. Current Powder River basin, Wyoming coal prices are \$0.49 MMbtu (million British thermal units) and Uinta basin coal prices (more typical of Colorado coals) are \$1.68 per MMbtu. Henry Hub natural gas prices have dropped from about \$9 per MMbtu in 2008 to \$2.64 per MMbtu in 2015, lessening the disparity between coal and natural gas prices; and
3. The declining cost and related growing use of renewable energy sources.

Colorado is one of the nation's leading renewable energy states, developing a portfolio mix of wind, solar, biomass, and hydroelectric energy resources. Colorado statute mandates that investor owned utilities generate 30% of electricity from renewable energy by 2020. Cooperatives must achieve a 20% standard by that same year. From 2005 to 2015, Colorado had a net increase in electricity generation of 3.3 billion kilowatthours, all from wind and solar. This was the highest increase in renewables among the six Mountain region states.

In 2010, the Colorado State Legislature passed the Clean Air-Clean Jobs Act, which promoted replacement of six aging coal-fired power plants located in Front Range communities with natural gas plants. The 160 megawatt (MW) Arapahoe Station coal-fired plant in Denver was closed in 2013 and the 44 MW Clark plant in Cañon City was closed in 2012. The Cameo power plant near Grand Junction was shut down and demolished in 2013. Operators of the Cherokee power plant in Denver replaced its coal-fired units 1, 2, and 3 with a 580 MW natural gas-fired power plant in 2015. The one remaining coal-fired unit 4 will be converted to natural gas by 2017. The operators of the Valmont power plant east of Boulder will shut down the 186 MW coal-fired unit by 2017; however the 43 MW natural gas-fired unit will remain on line.

Coal production from Colorado mines in 2015 was 18.73 million tons, an 18% decline from the 2014 value of 22.98 million tons and a decline of 53% from the recent high value of 39.8 million tons in 2004. The value of Colorado coal production in 2015 was \$677 million, down 22% from the 2014 value of \$867 million (**Table 2-1 and Figure 2-1**). The average value of a ton of Colorado coal was \$36.12 in 2015, production since 2004 is shown in **Figure 2-2**. Employment in the Colorado coal mining industry in 2015 was 1,326 persons, a decline of 42 % from a recent high of 2,279 jobs in 2012 according to data provided by the Colorado Division of Reclamation, Mining, and Safety (**Figure 2-3**).

The two most important physical and chemical characteristics of coal that is used in power plants are its heat content and its chemical quality. Coal in Colorado that is mined today ranges in heat content from subbituminous to bituminous. Subbituminous coal has a heat value of 8,500 to 13,000 British thermal units per pound (Btu/lb.) and bituminous coal has a heat value of 11,000 to 15,000 Btu/lb. (Indiana Center for Coal Technology Research).

**Table 2-1. Coal production, price, value, and employment, 2001–2015.**

Year	Production Short Tons (Millions)	Colorado Average Annual Coal Price \$/Short Ton	Product Value (Millions)	Coal Miner Employment
2001	33.41	\$17.30	\$578	1,761
2002	35.20	\$18.44	\$649	1,854
2003	35.88	\$19.59	\$703	1,859
2004	39.81	\$20.09	\$800	1,903
2005	37.82	\$21.50	\$813	1,963
2006	35.49	\$27.44	\$974	2,065
2007	36.14	\$26.20	\$947	2,069
2008	32.34	\$28.81	\$932	2,124
2009	28.58	\$31.29	\$894	2,247
2010	25.21	\$30.66	\$773	2,061
2011	27.03	\$33.77	\$913	2,254
2012	28.04	\$37.54	\$1,053	2,279
2013	24.27	\$37.58	\$912	1,857
2014	22.98	\$37.75	\$867	1,512
2015	18.73	\$36.12	\$677	1,326

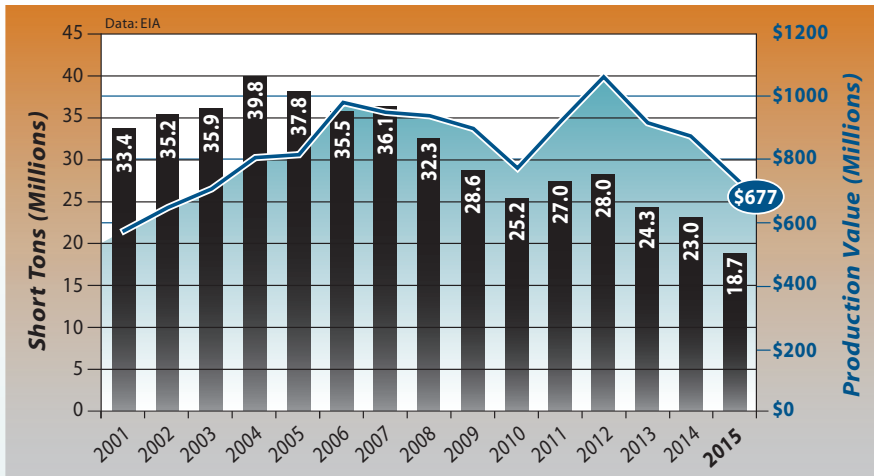


Figure 2-1. Production and value of coal mined in Colorado, 2001–2015.

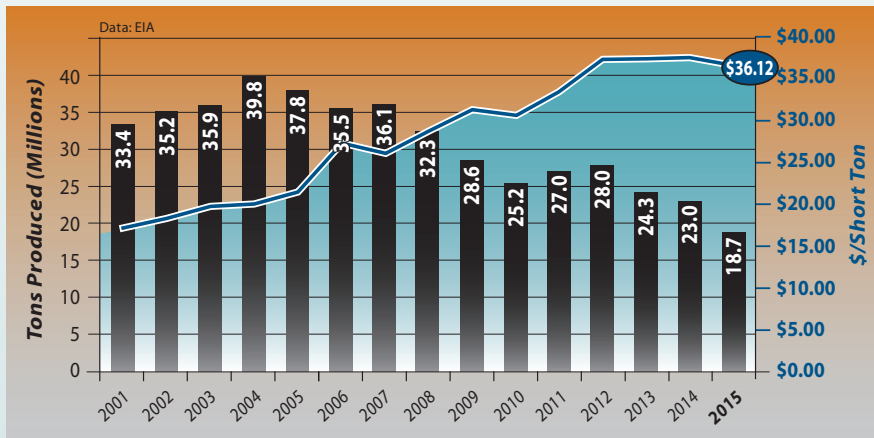


Figure 2-2. Coal production and average yearly coal price in Colorado, 2001–2015.

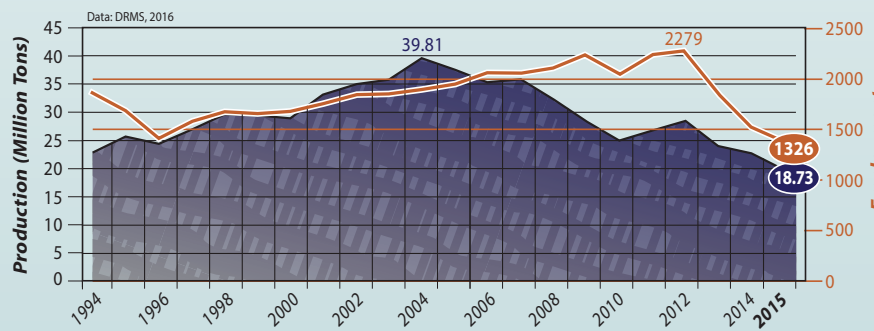


Figure 2-3. Coal production and employment in Colorado, 1994–2015.

Colorado, along with other western states, has high quality coal:

- Average ash content of Colorado coal ranges from 6.4 % in the South Park region to 12.7% in the San Juan region.
- Average sulfur content varies from 0.3% in the Denver region to 0.8% in the Cañon City and San Juan regions.
- Average mercury content varies from 0.02 parts per million (ppm) in the Green River and Uinta regions to 0.185 ppm in the Cañon City region (Table 2-2).

Table 2-2. Colorado average coal quality for mineable coal beds by coal region.

Analyses	Denver Region	Green River Region	North Park Region	Raton Mesa Region	San Juan Region	Uinta Region	South Park Region	Canon City Region
Ash %	11.2	9	12.4	16.1	12.7	6.8	6.4	9.8
Sulfur %	0.3	0.6	0.5	0.7	0.8	0.6	0.5	0.8
BTU (per lb.)	9,072	10,973	9,483	12,541	12,758	11,879	9,780	11,130
Mercury (ppm)	---	<0.02	---	0.035	0.03	0.02	---	0.185

Mercury values are from the U.S. Geological Survey National Coal Quality Inventory at active mines in 2001 (Colorado Geological Survey Information Series 58).

Average coal quality values from eastern and central U.S. coal regions and Colorado are compared in Table 2-3. Eastern and central U.S. coalfields have much higher sulfur and mercury contents than Colorado coal. Colorado coal, because of its low sulfur and mercury contents, is often shipped to eastern power plants and mixed with local coal to help those plants meet air quality standards.

Table 2-3. Colorado average coal quality and average coal quality in other U.S. coal producing regions.

Analyses	Colorado Average (from Table 2)	Central Appalachian Region	Illinois Basin
Ash %	10.55	7.24	11.10
Sulfur %	0.60	1.05	3.0
Btu (per lb.)	10,952	13,540	11,200
Mercury (ppm)	0.06	0.21	0.12

Eight Colorado coal mines were active in 2015, down from nine in 2014. (Table 2-4). Declines in the coal industry have greatly impacted the economies of Colorado rural communities. Three large mines; Foidel Creek in Routt County, West Elk in Gunnison County, and the Bowie #2 in Delta County all

**Table 2-4. Active coal mines in Colorado, 2015.**

Mine	Operator	County	Mine Type	2015 Production (tons)
Bowie #2	Bowie Resources Ltd.	Delta	Underground	1,587,976
Colowyo	Colowyo Coal Co. L.P.	Moffat	Surface	2,321,851
Deserado	Blue Mountain Energy	Rio Blanco	Underground	2,353,043
Foidel Creek	Twenty Mile Coal Co.	Routt	Underground	4,121,191
King II	National King Coal LLC.	La Plata	Underground	813,677
New Horizon North	Western Fuels-CO LLC	Montrose	Surface	238,094
Trapper Strip	Trapper Mining Co.	Moffat	Surface	2,117,628
West Elk	Mountain Coal Co.	Gunnison	Underground	5,172,878
<b>Total</b>				<b>18,726,338</b>

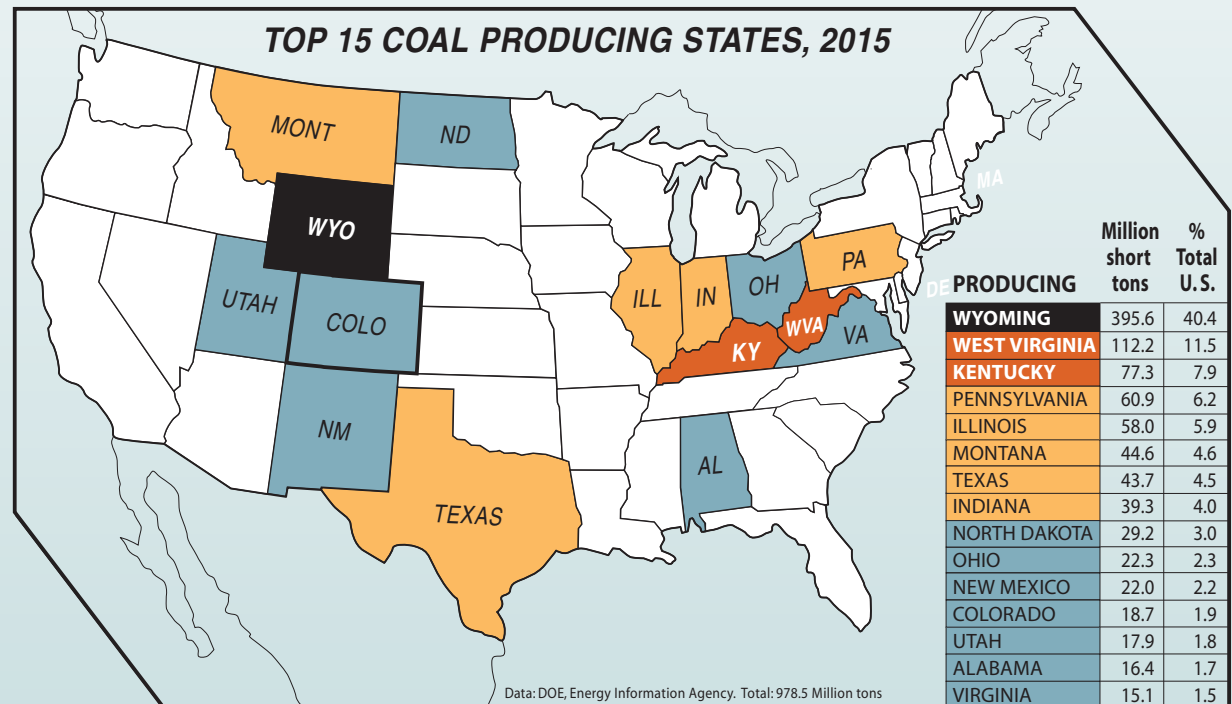


**Bowie #2 stockpile.** Photo CGS archive.

Data: Colorado Division of Reclamation, Mining and Safety (DRMS).

had significant cuts in 2015 coal production and employment from the already reduced values in 2014. The Colowyo Mine, near Craig in Moffat County, was facing a revocation of its revised 2007 operating permit from the Office of Surface Mining Reclamation and Enforcement (OSMRE) due to a lawsuit from Wild Earth Guardians. The lawsuit charged that the OSMRE environmental assessment did not take into account the effect on climate change caused by the direct and indirect impacts of mining and burning coal. OSMRE completed the court-ordered review and found no significant environmental impacts; therefore, allowing the Colowyo Mine to continue production. In 2016, depressed coal prices forced Bowie Resource Partners to idle the Bowie #2 Mine in Delta County with a resulting loss of 108 full-time jobs.

In 2015, Colorado was ranked 11th in coal production in the U.S. (**Figure 2-4**). Wyoming, the leading U.S. producer by far, mined 21 times as much coal as Colorado. The locations of Colorado's active coal mines, coal-fired power plants, and coal regions showing the types of contained coal are shown on **Figure 2-5**.



**Figure 2-4. Top 15 coal-producing states in 2015.**

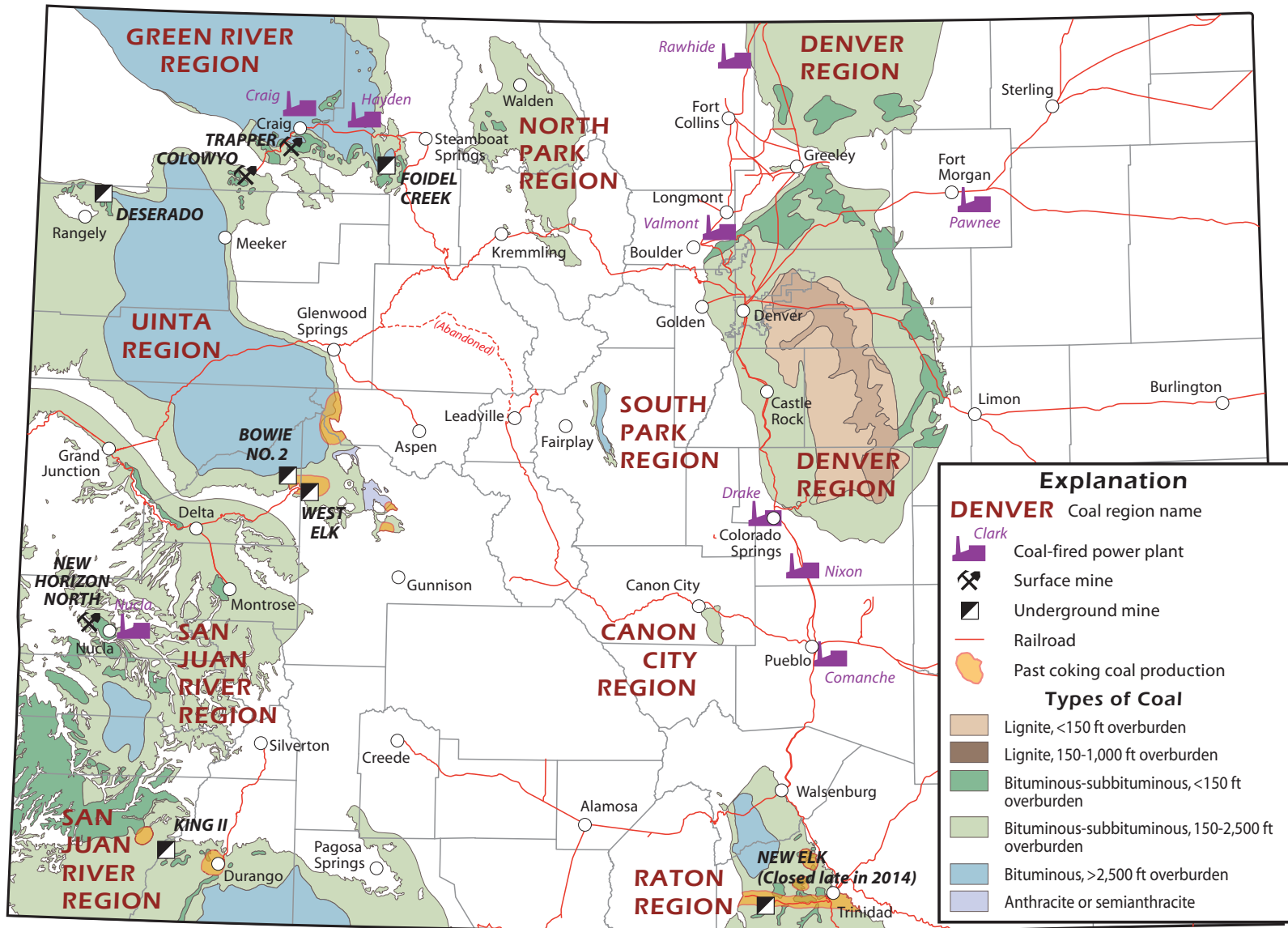


Figure 2-5. Locations of active coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2015.

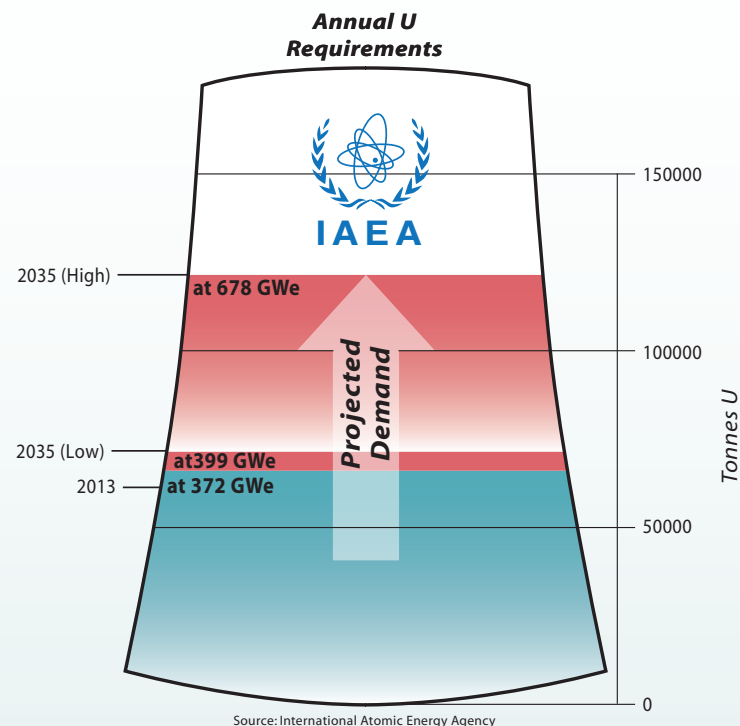
## 3.0 URANIUM

According to the Nuclear Energy Institute, nuclear energy has accounted for approximately 18 to 20.6% of the total electricity generated in the U.S. since 1990. The U.S. is the world's largest producer of nuclear power with 99 operating nuclear reactors that produced 798 billion kilowatt hours (kWh) in 2015. Nuclear energy production accounted for approximately 19.5% of the total electricity generated in the U.S. in 2015. Colorado is one of about twenty-one states that did not generate electricity from nuclear energy in 2015. Over 82% of the electricity generated in Colorado during 2015 was from coal and natural gas. Electricity generated from wind in Colorado accounted for about 14% of the total. Other minor sources of electrical generation within Colorado included hydroelectric (2.3%) and solar (0.6%).

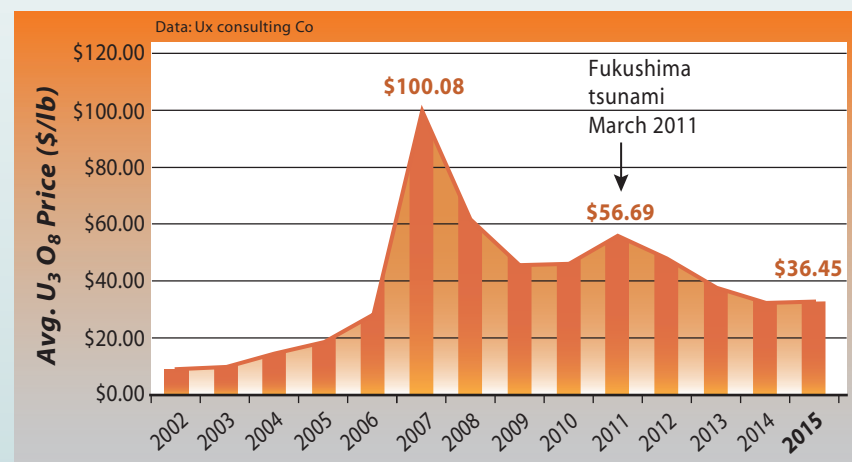
International Atomic Energy Agency (IAEA) data indicate that the world consumed 372 Gigawatt-electric (GWe) in 2013. By the year 2035, annual consumption of nuclear-generated power is estimated to range from 399 GWe to 678 GWe (**Figure 3-1**), depending on several variables and scenarios. Considering the projections for increased nuclear power generation worldwide by 2035, there may be an increase in uranium demand without significant increases in exploration and development of uranium resources to meet the demand.

Currently, most of the U.S. nuclear power is generated by reactors built between 1967 and 1990. Four nuclear power reactors are currently being built in the U.S. Construction on these reactors started in 2013 and they are scheduled to start operation in 2019-20. Additionally, 60 new nuclear reactors are under construction worldwide at the time of this report. Prices may rise in response to new construction activity as the need for additional uranium increases with each nuclear start up.

**Figure 3-2** shows the average annual uranium prices since 2002. Although the average price of triuranium octoxide ( $U_3O_8$  - a popular form of uranium concentrate or yellowcake) increased slightly in 2015, from \$33.27 in 2014 to \$36.45 per pound, prices have been trending downward since 2007 and after the 2011 Fukushima, Japan accident. The EIA estimated a total U.S.  $U_3O_8$  production for 2015 of 3.3 million pounds which is about 24% lower than the 2014 production of 4.9 million pounds. Reportedly, the 2015  $U_3O_8$  production is about 7% of the projected yearly uranium market requirements for the U.S. A summary of  $U_3O_8$  production in the U.S. since 1996 is included in **Figure 3-3**.



**Figure 3-1. Projections of future world uranium requirements.**



**Figure 3-2. Average annual  $U_3O_8$  price per pound, 2002–2015.**

There are currently no operating uranium mines or mills in Colorado although it has been a producer in the past. Texas, Wyoming, Arizona, and Nebraska were the only states with producing in-situ leach operations in 2015. These mines produced the majority of uranium in the U.S. Utah has the only fully-licensed and operating conventional uranium mill in the U.S.

### 3.1 URANIUM EXPLORATION AND DEVELOPMENT IN COLORADO

According to the EIA, uranium exploration and development drilling activity for the U.S. decreased from 1.3 million feet of drilling in 2014 to 0.9 million feet in 2015. Estimated uranium exploration and development expenditures increased slightly from \$28.2 million in 2014 to \$28.7 million in 2015. Even though a number of mines and a mill are permitted in Colorado, there was little activity reported from these facilities. There was some activity with regards to takeovers and other corporate news among companies that own uranium properties in Colorado. A few of the uranium projects and companies associated with Colorado uranium are discussed below.

Energy Fuels Inc. has headquarters in Colorado and owns the Whirlwind Property located in Mesa County as well as the only conventional uranium mill operation in the U.S. According to Energy Fuels, the Whirlwind Property is an underground mine containing 169,000 tons of indicated resources containing 1.0 million pounds of  $U_3O_8$ . Inferred resources totaled 437,000 tons containing 2.0 million pounds of  $U_3O_8$ . Reportedly, this mine is fully permitted, developed, and awaiting higher uranium prices. Energy Fuels Inc. also completed its takeover of Uranerz Energy Corp. in 2015 and now owns the Nichols Ranch In-Situ Recovery Mine and Plant located in Wyoming.

Western Uranium Co. (Western) completed their takeover of Black Range Minerals in 2015. Through this acquisition, Western acquired the Hansen-Taylor Complex uranium property and a 100% interest in a 25 year license for ablation mining technologies and related patents. The Hansen-Taylor uranium

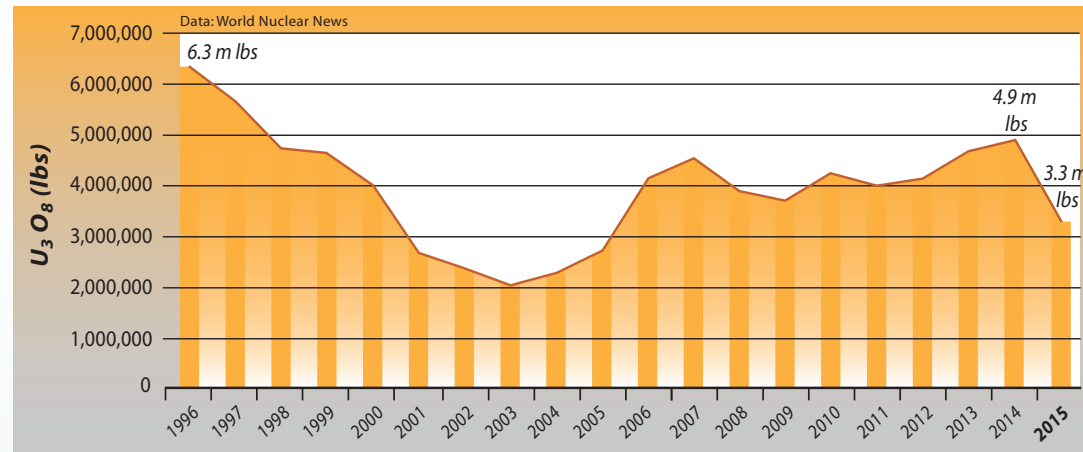


Figure 3-3. Annual production of uranium concentrate in U.S., 1996–2015.

deposit is located in the Tallahassee Creek mining district north of Cañon City in Fremont County. The ablation process is a lower cost grain-size separation process for concentrating uranium mineralization. Western has additional options to acquire other mineral interests within the Hansen-Taylor Complex. Western also owns land associated with the Pinon Ridge Properties, the Sunday Mine Complex located in San Miguel County, the Farmer Girl Mine project located in Montrose County, and the Sage

Mine located in San Miguel County. In connection with the Black Range takeover, Western acquired additional mineral properties in Colorado including the Keota deposit in Weld County, and the Hansen, North Hansen, High Park, Hansen Picnic Tree, Taylor Ranch, and Boyer Ranch mining properties located in Fremont County. The Pinon Ridge Mill is currently permitted/licensed but did not operate in 2015.

On October 29, 2014, Azarga Resources completed a merger with Powertech Uranium Corp. and changed the name of the merged company to Azarga Uranium Corp. Among the new company's many assets in other states is the Centennial uranium property in Weld County, Colorado. According to an investor presentation on the Azarga website, this property contains indicated resources of 10.3 million pounds of  $U_3O_8$  and inferred resources of 2.3 million pounds of  $U_3O_8$  at an average grade of 0.09%. In an interview with the Azarga Uranium chairman in late-2014, it was reported that multiple mine plans were prepared for the Centennial property and that this project was not on the back burner.

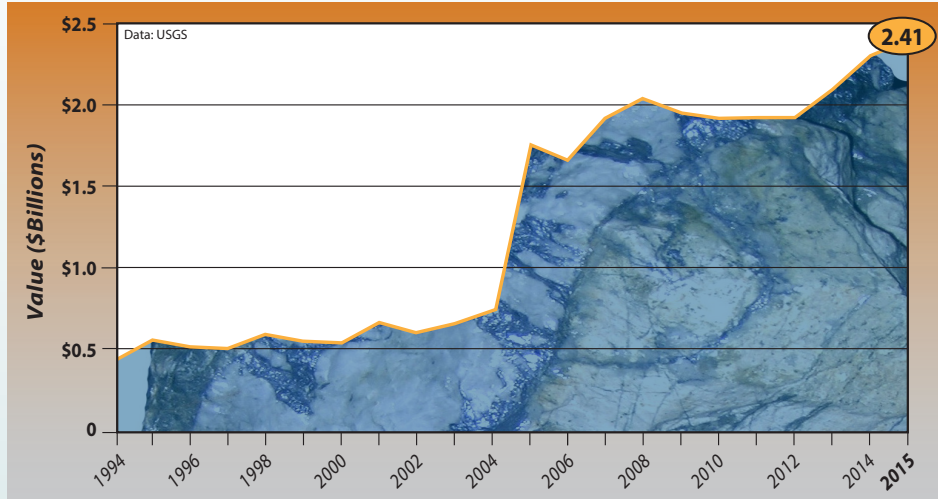
Uranium Energy Corp (UEC) currently owns claims or has projects at their Carnotite, Long Park, Radium Mountain, Raven, and Slick Rock properties located in Colorado. The UEC plans to confirm historic resource estimates at some of these properties. UEC completed an inferred uranium resource estimate in 2014 at their Slick Rock property which includes 2.5 million tons of ore containing 11.6 million pounds of  $U_3O_8$  at a cut-off grade of 0.15%  $U_3O_8$ .



# NONFUEL MINERAL RESOURCES

## 4.0 NONFUEL 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. 2015 nonfuel mineral production value was \$77.6 billion. Colorado ranked 12th in the U.S. for 2015, as it did in 2014, and produced \$2.41 billion, or about 3.1%, of the estimated total production value. The 2015 estimated value for Colorado was about 3.7% higher than the USGS 2014 total production value estimate of \$2.32 billion and more than triple the 2004 value of \$762 million. **Figure 4-1** shows the growth of nonfuel mineral production value in Colorado since 1994. The rapid increase in value from 2003 and 2008 was mainly due to rising prices for both molybdenum and gold.



**Figure 4-1. Total nonfuel mineral production value in Colorado, 1994–2015.**

## 4.1 METAL MINING

Metals mined in Colorado include molybdenum, gold, and silver. The CGS estimates that the 2015 production value of these metals was about \$552 million. This is about a 34% decrease compared to the 2014 production value of \$893 million. The decrease in value was due to the decrease in molybdenum, gold, and silver prices as well as decreases in molybdenum and gold production.

### 4.1.1 MOLYBDENUM

According to the International Molybdenum Association, 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 in agriculture. Superalloys are generally nickel-based alloys that are combined with molybdenum and other elements to produce corrosion-resistant and high-temperature alloys. Stainless steel generally refers to steel made from iron alloys that contain chrome. The chromium content determines if the steel is stainless and the addition of molybdenum improves the resistance of stainless steel to corrosion.

According to the USGS, the U.S. was the second largest producer of molybdenum in the world and produced an estimated 56,300 metric tons in 2015 valued at an estimated \$1.0 billion based on average prices. This was approximately 17% lower than the 2014 estimated molybdenum production of 68,200 metric tons. China was the number one producer (estimated 101,000 metric tons in 2015) and Chile was the third largest producer (estimated 49,000 metric tons in 2015). The average price of molybdenum in 2015 was about \$6.66 per pound.

Colorado's molybdenum production and the average annual molybdenum trioxide ( $\text{MoO}_3$ ) price, from 1995 to 2015, are shown in **Figure 4-2**. A majority of the 2015 molybdenum production in the U.S. was from two Colorado mines (**Figure 4-3**) that produced approximately 21,790 metric tons combined. In Colorado, molybdenum is mined at the Climax and Henderson mines by Freeport-McMoRan Inc. (Freeport). Freeport estimates that it had a direct impact of about \$252.8 million on Colorado's economy in 2015 which included compensation, business taxes, and vendor purchases. Reportedly, indirect impacts added another \$229.7 million to the economy through spending by employees, new tax revenues, pension incomes, and vendor purchases.

The Climax open-pit mine is located northeast of Leadville, at Fremont Pass, and operates a 25,000 metric ton per day mill. The mine reopened in May of 2012 after being shut down for 17 years. Climax has the ability to produce about 30 million pounds of molybdenum per year. Climax molybdenum production was approximately 23 million pounds in 2015, 21 million pounds in 2014, and 19 million pounds in 2013. Proven reserves at the Climax mine were estimated at 155 million metric tons at the end of 2015.

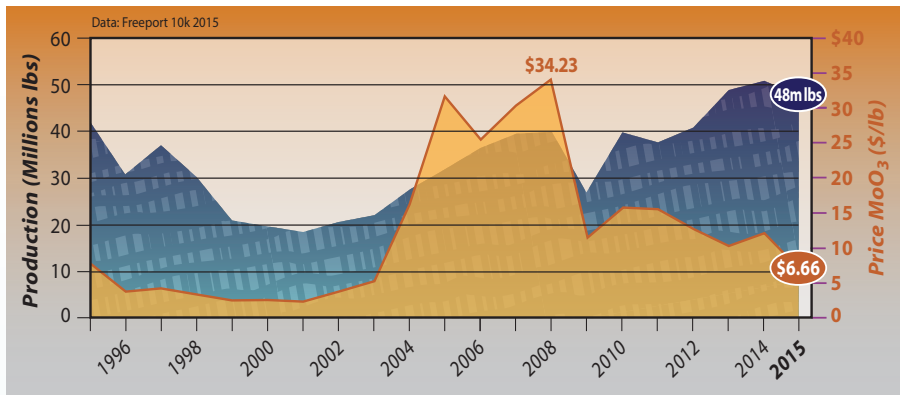


Figure 4-2. Colorado molybdenum production and average annual price per pound, 1995–2015.

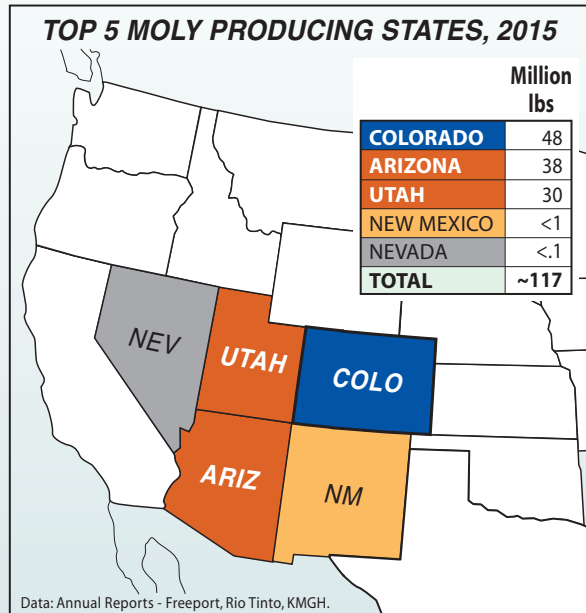


Figure 4-3. Top five molybdenum producing states, 2015.

The Henderson mine is located near Empire. This operation is a large block-cave underground mine connected to a 32,000 metric tons per day concentrator by a 15-mile conveyor tunnel. Revised plans for the Henderson mine include a 65% reduction in operating rates. Henderson molybdenum production totaled 25 million pounds in 2015 and 30 million pounds in both 2014 and 2013. In December 2015, the Denver Post reported that Freeport may be closing the Henderson Mine in three to five years instead of the 10 years that

they had expected. The Denver Post reported this mine accounted for 70 percent of all property taxes collecting in Clear Creek County and about 36% of the county budget (<http://www.denverpost.com/2015/12/10/looming-henderson-mine-closure-stokes-big-fears-in-clear-creek-county/>). Proven reserves at the Henderson mine were estimated at 65 million metric tons at the end of 2015.

#### 4.1.2 GOLD AND SILVER

In 2015, gold was primarily mined to be used in jewelry (43%), electrical and electronics (37%), coins (15%), and other (5%) uses which may include dentistry, medicine, and aerospace equipment (e.g. to reflect infrared radiation). According to the USGS, U.S. gold production decreased from 210 metric tons in 2014 to 200 metric tons in 2015 with an estimated value of \$7.6 billion. In 2015, the U.S. was the fourth largest producer of gold in the world following China (490 metric tons), Australia (300 metric tons), and Russia (242 metric tons). **Figure 4-4** shows the price of gold and Colorado gold production from 1990 to 2015. Colorado was the third top producer of gold (197,645 ounces) in the U.S. (**Figure 4-5**) following Nevada (3.94 million ounces) and Utah (400,000 ounces) in 2015. The average gold price in 2015 was \$1,170 per ounce.

U.S. production of silver in 2015 was estimated at 1,100 tons with an estimated value of \$560 million. This was a slight decline from the estimated 2014 production of 1,180 tons. The U.S. was ranked tenth in silver production in 2015 behind Mexico (5,400 tons), China (4,100 tons), and Peru (3,800 tons). The 2015 uses of silver were estimated and include electrical/electronics (29%), coins/medals (25%), photography (8%), jewelry/silverware (7%) and other

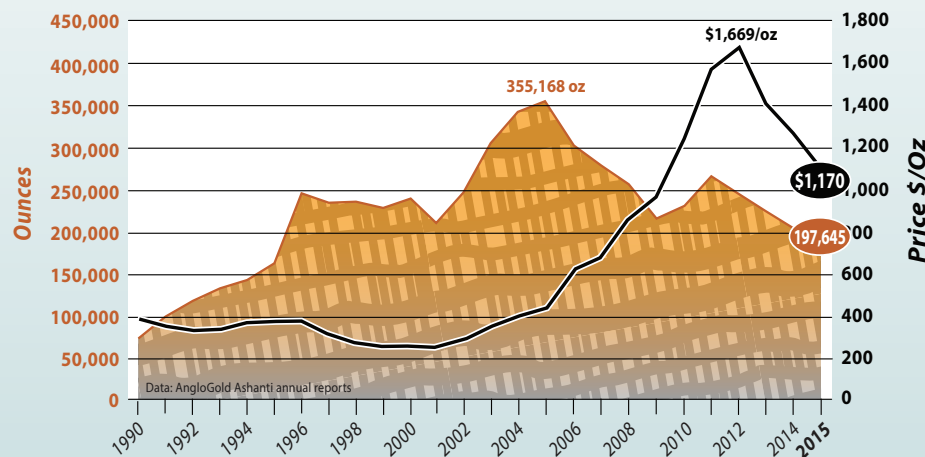


Figure 4-4. Colorado gold production and average annual price per ounce, 1990–2015.

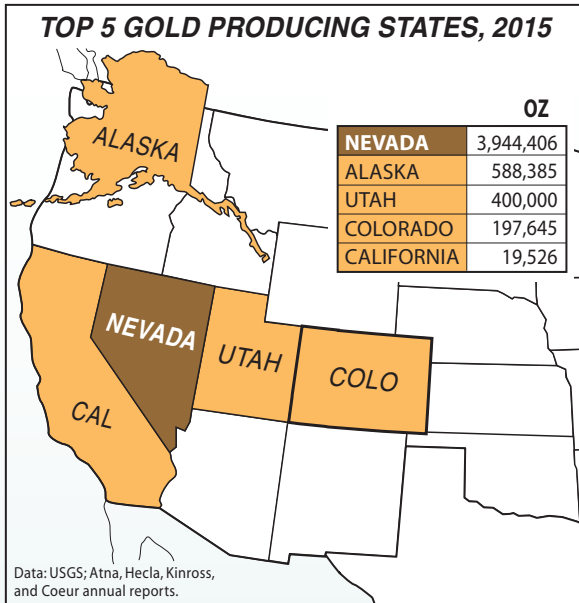


Figure 4-5. Top five gold producing states, 2015.

applications (31%) which may include items such as antimicrobial bandages, clothing, pharmaceuticals, plastics, and batteries. **Figure 4-6** shows Colorado silver production and the average annual price per ounce between 2005 and 2015. The average 2015 price of silver was \$16 per ounce.

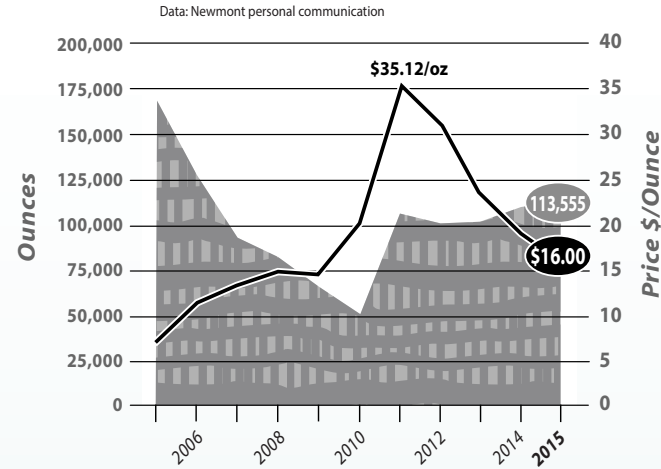
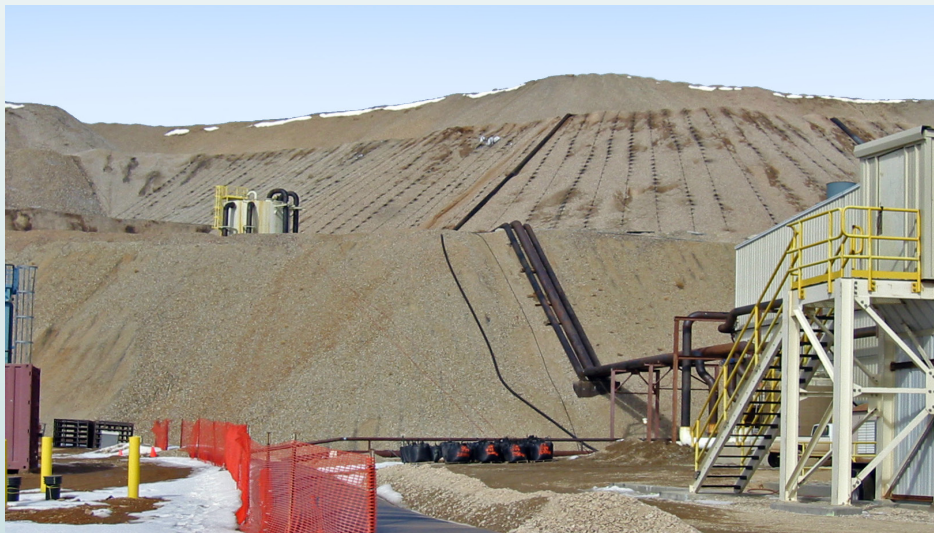


Figure 4-6. Colorado silver production and average annual price per ounce, 1990–2015.

In August of 2015, Newmont Mining completed their takeover of the Cripple Creek and Victor Gold Mining Company (CC&V), located near the town of Victor, CO, from AngloGold Ashanti Limited. Newmont Mining was the second largest producer of gold in the world in 2015. Their corporate headquarters is located in the Denver area. A new leach pad and recovery plant are currently under construction and construction on a new mill was completed in 2015. Mine exploration and ore reserve development is ongoing on the property. Reportedly, CC&V produced an estimated 81,000 ounces of gold between August and December, 2015, and has about 3.8 million ounces of proven and probable gold reserves. According to a personal communication with Newmont, CC&V produced about 197,645 ounces of gold and 113,555 ounces of silver in 2015. This was a decrease from CC&V's production in 2014 which was 200,000 ounces of gold and 110,373 ounces of silver.

A small amount of placer gold is occasionally 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 38 active gold mining permits in the DRMS database.

The Revenue Mine is located in Ouray County near the town of Ouray. The mine is owned by Lascaux Resource Capital (LRC) after the former owner, Fortune Minerals, defaulted on a \$35 million agreement with LRC in 2015 due to lower silver prices, slower than expected increase in production, and other complications. Fortune Minerals subsequently resolved its obligations with LRC.



CC&V Heap leach pad outside of Victor. Photo CGS archive.

Since about July 2015, the mine has been focusing on care and maintenance activities. Reportedly, LRC is working with Fairplay Minerals, based in Colorado, to evaluate the mine and has agreed to a joint venture project. In 2014, it was reported that the mine produces primarily silver (mine plan average grade of 14.6 ounce per ton (oz/ton)), with byproduct credits of gold (0.02 oz/ton), lead (2.26%) and zinc (0.90%).

#### 4.1.3 METAL EXPLORATION AND DEVELOPMENT ACTIVITIES

The precious metal exploration industry worldwide has been hurt by falling metals prices since 2012. This downward price trajectory has made it difficult for most companies to raise financing for exploration. SNL Metals & Mining reported that worldwide exploration budgets for nonferrous metals declined 19% in 2015 compared to 2014. They also report that the budget for nonferrous metals worldwide was at about \$9.2 billion or approximately 57% lower than the 2012 budget of \$21.5 billion. Exploration and development projects in Colorado, as reported in the 2014-2015 CGS Mineral and Energy Industry Activity report and updated here, that have undergone at least some activity in the past years are discussed below:

*The Golden Wonder Mine* is a high grade telluride gold vein deposit located near Lake City. LKA International, Inc. (LKA), is currently establishing mine reserves at the property. Between 1998 and 2007, the average ore grade was 16.01 ounces of gold per ton. According to an early-2015 LKA progress report, a drilling program is being conducted at the mine. Initial drilling results have identified high-grade veins near the existing underground mine. Future drilling will concentrate on the Golden Wonder vein trend and unexplored areas of the vein system between the historic underground mine workings and the vein trend. LKA's exploration program is, at least, partially funded by ore sales from the mine. After the first quarter of 2009, when LKA resumed exploration at the mine, 35 bulk ore samples that contained over 4,600 ounces of gold were sent for processing and had a net value of more than \$5 million. In mid-2015, LKA announced it had executed an agreement with Kinross Gold U.S.A. to expand mine exploration beyond the Golden Wonder active workings. An initial exploration report released in early-2016 indicated several potential targets that reportedly possess similar characteristics to targets at the surface above the previously mined area.

*The Dawson Property* is located southwest of Canon City. Zephyr Minerals Ltd. (Zephyr) holds 100% interest in 45 unpatented claims and other interests in additional patented claims and one patented placer claim associated with this property. The Dawson Property comprises three mineralized areas including the Dawson segment, the Windy Point segment, and the Windy Gulch segment. Zephyr indicates that the Dawson and Windy Gulch segments contain an inferred resource of 392,000 metric tons at 10.5 grams per metric ton gold,

containing about 132,300 ounces of gold, using a 5 gram per metric ton cut-off and capped at 40 grams per metric ton of gold. At the time of this report, Zephyr reported that it completed a limited drill program in 2016 and that a preliminary process plant design, preliminary tailings dam design, and additional gold targeting/modeling are currently underway.

*The San Juan Silver Project* is located in the Creede mining district in Mineral County. Rio Grande Silver, Inc., a wholly owned subsidiary of Hecla Mining Company (Hecla), owns the San Juan Silver project which includes the Bulldog Mine and Equity/Amethyst vein systems. A 2015 Hecla reserve and resource update indicate that the San Juan Silver Project contained an indicated resource of about 7.6 million ounces of silver and an inferred resource of about 33 million ounces of silver. Future plans are focused on permitting associated with water discharge and an amendment to the operation plan for surface exploration drilling.

*U.S. Energy Corp.* has controlled the Mount Emmons molybdenum deposit for many years. The project, located near Crested Butte in Gunnison County, contains a historical resource of 220 million tons of 0.366% MoS<sub>2</sub>, and was on "care and maintenance" status prior to 2015. The mine proposal has met strong resistance from environmental groups over the years since it was first discovered in the 1970s. At the time of this report, the Freeport McMoRan subsidiary, Mt. Emmons Mining Company (MEMC), had acquired the Mt. Emmons mine property and a related water treatment facility associated with the historic Keystone Mine from U.S. Energy. An agreement between MEMC, state health department, and other agencies will reportedly ensure ongoing water treatment which prevents impacts to Coal Creek which is tributary to the Gunnison River.

*U.S. Rare Earth Inc.* (USRE) has mining claims at two rare earth mineral occurrences in Colorado including the Wet Mountain deposits, located in Custer and Fremont counties, and the Iron Hill carbonatite complex located in Gunnison County. USRE did not indicate on their website that any exploration or development activities were conducted on these properties in 2015. USRE did enter into agreements with Oak Ridge National Laboratory in 2015 which included a licensing agreement for the extraction process of specific elements from mining materials as well as recycling of specific rare earth elements from electronic waste.

Vanadium in Colorado is generally associated with the sandstone-hosted uranium deposits located in western Colorado, specifically on the Colorado Plateau. Because of low uranium and vanadium prices, there are currently no mines in production. The last vanadium production reported was in 2005. If Colorado uranium mining resumes in the future, vanadium would likely be produced as a by-product of uranium mining.

# INDUSTRIAL MINERALS and CONSTRUCTION MATERIALS

## 4.2.1 AGGREGATE - SAND, GRAVEL, AND CRUSHED STONE

The primary uses of sand, gravel, and crushed stone are concrete (road base, coverings, paver base, walkways, bedding, and many more), construction fill, and asphaltic concrete. The DRMS database lists over 1,000 active permits for aggregate quarries in Colorado. Most of these are alluvial sand and gravel quarries. Aggregate mining operations vary in size from small “mom and pop” operations on three acres to large quarries over 500 acres in size.

The USGS estimates that Colorado quarry operators produced 50.9 million tons of aggregate (sand and gravel and crushed stone) in 2015, a slight decrease of 1.5% from the 2014 production value of 51.7 million tons (Figure 4-7).

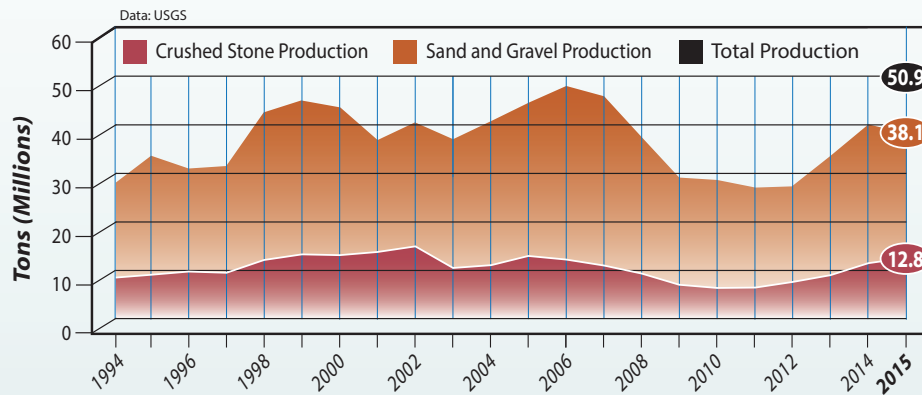


Figure 4-7. Aggregate production in Colorado, 1994–2015.

- Sand and gravel production in 2015 totaled 38.1 million tons, a decrease of 4.8 % from the 40.0 million tons produced in 2014. According to the USGS, the average price during 2015 for sand and gravel aggregate was \$8.29 per ton, a slight increase of 3.6 % from the 2014 value of \$8.00 per ton (Figure 4-8). The total value of the 2015 sand and gravel production was \$315.85 million, a slight decline of 1.3% from the \$320.00 million value in 2014.
- Crushed stone production in 2015 rose to 12.8 million tons, a 9.4% increase from the 11.7 million tons produced in 2014. According to the USGS, the average price during 2015 for crushed stone aggregate was \$8.51 per ton, a negligible decrease of 0.1% from the 2014 value of \$8.52 per ton (Figure 4-9). The total value of the 2015 crushed stone

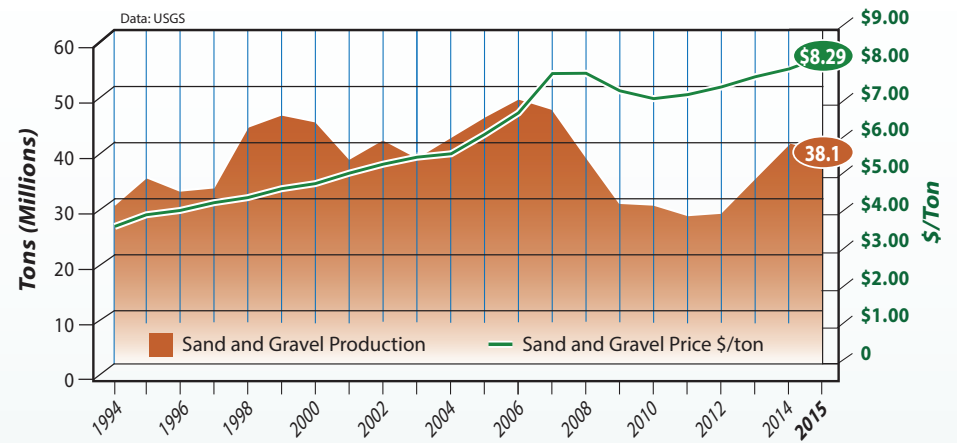


Figure 4-8. Price and production of sand and gravel aggregate in Colorado, 1994–2015.

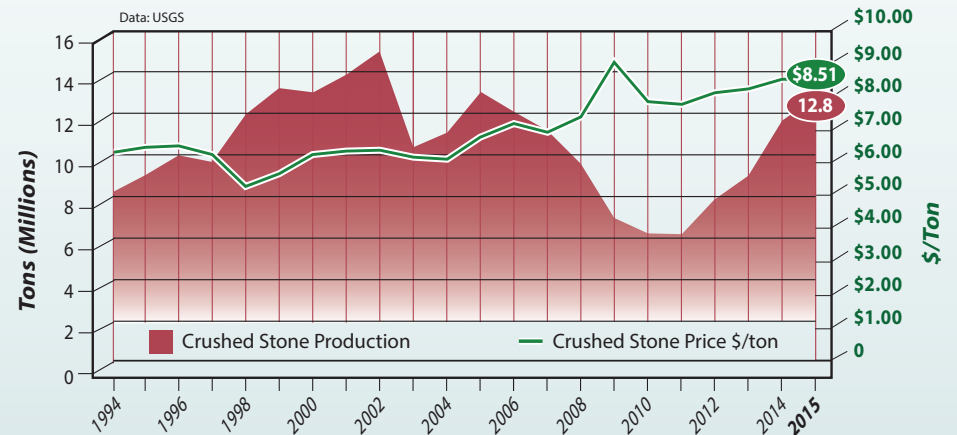


Figure 4-9. Price and production of crushed stone aggregate in Colorado, 1994–2015.

production was \$108.92 million, an increase of 9.3 % from the \$99.68 million value in 2014.

The combined value of all aggregate (sand and gravel, and crushed stone) production in 2015 was \$424.8 million, a slight increase of 1.2% from the 2014 value of \$419.7 million.



**Pikeview quarry aggregate hauling, and conveyors (page 25), El Paso County.**  
*Photos Matt Morgan.*

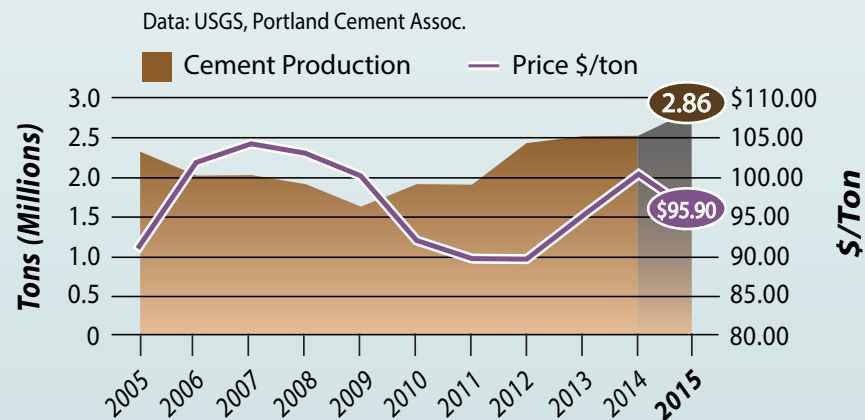
Aggregate production started to decline in the 2005-2006 time period; possibly reflecting the harbinger of the 2008 “Great Recession”. Production began to increase sharply between 2010 and 2011 with the resurgence of Colorado’s economy, especially the housing market. The number of available residential units has not kept pace with the growth in Colorado’s population, a trend that started in 2000 and became aggravated in 2008. According to the Colorado Business Outlook Report by the Leeds School of Business at CU Boulder (2016), residential building permits have increased from 9,355 in 2009 to an estimated 32,300 in 2015, with most of the activity centered along the Front Range (Colorado Springs, Denver, Aurora, and Fort Collins). Aggregate production will likely continue to grow over the next few years as no reduction in population growth is expected in Colorado.

Aggregate is a high bulk, low unit cost commodity and, therefore transportation costs from quarry to construction sites are an important factor in the overall cost of aggregate. Ideally, aggregate should be mined as close as possible to construction sites. Most of the current residential construction activity in Colorado is occurring near Front Range cities where land-use issues can be in conflict between construction companies, quarry operators, local governments, and citizens interested in land preservation and recreation. Planning is required to prevent quality aggregate resources from being sterilized by residential and

non-residential construction. In order to facilitate planning for urban and suburban growth, the CGS undertook mapping of the Front Range Urban Corridor’s sand and gravel resources in the 1970s. Those maps are summarized in “Colorado Geological Survey Atlas of Sand, Gravel and Quarry Aggregate Resources, Colorado Front Range Counties.” The aggregate resource maps (1:24,000 scale) were converted to a digital format in a cooperative effort between the USGS and CGS.

#### 4.2.2 CEMENT

Portland cement in Colorado is used primarily in the production of concrete. Concrete consists of fragments of crushed rock or gravel in a paste of cement. Three large portland cement plants operated in Colorado during 2015: Holcim (US) Inc. in Florence, the GCC of America plant in Pueblo, and the CEMEX plant near Lyons. GCC of America and CEMEX are Mexico-based multinational companies. Holcim (US) Inc. is a subsidiary of LafargeHolcim, a large multinational company based in Switzerland. 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. Cement production in the Colorado in 2015 was 2.86 million tons, up 5.9% from the 2.7 million tons produced in 2014, as reported by the Portland Cement Association. The average cement price per ton in 2015 was \$95.90, a 2.6% decline from the \$98.50 value in 2014 (**Figure 4-10**).



**Figure 4-10. Price and production of cement in Colorado, 2005–2015.**

### 4.2.3 CLAY AND SHALE

Common clay is mined primarily in eastern Colorado along the Front Range and is used mostly to make bricks and tiles. Higher quality clays are mined from the claystone and shale deposits in the Dakota Group and the Dawson Arkose/Denver Formation and are used in the manufacture of refractory ware, such as crucibles and high temperature fire bricks for kilns. According to the USGS, Colorado clay miners produced 197,300 tons of common clay in 2014, a decline of 4.3% from the 206,100 tons in 2013. Production values for 2015 were not available at this writing. The value of common clay is approximately \$10.00 per ton. The value of 2014 clay production is estimated at \$1,973,000. The USGS withholds production statistics for fire clay and bentonite.

Three large brick companies currently operate in the Denver area: Acme Brick Co., Robinson Brick Co., and Summit Brick Co. Rio Grande Bentonite operates a small bentonite mine near Antonito in Conejos County. Bentonite clays are mined for specialty purposes, such as kitty litter or as an absorbent to clean up hazardous spills. A small amount of fire clay was produced as well. As with other construction material, clay production has increased substantially since the “Great Recession” of 2007-2009 (Figure 4-11).

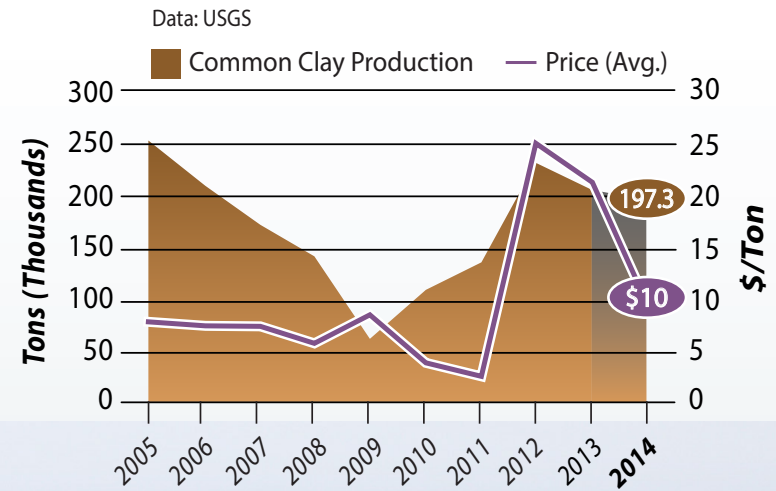


Figure 4-11. Production and average price of common clay in Colorado, 2005–2014.



#### 4.2.4 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 glassmaking and smelting. Increased construction activity in Colorado will have a positive impact on the company's production. Production information from the USGS for Colorado gypsum manufacturers is not available due to proprietary reasons.

American Gypsum Co. operates a large quarry and fabrication plant for wallboard in Eagle County, near the town of Gypsum. In recent years, the plant produced approximately 600 million square feet of wallboard. Colorado Lien Co. produces gypsum mostly for the cement industry from the Munroe Quarry north of Fort Collins, Larimer County. Holcim (US) Inc., a large cement manufacturer, operates the Coaldale quarry in Fremont County southeast of Salida. US Soil Conditioning Co. operates the small Maverick Placer gypsum mine also east of Salida. GCC of America runs the Salt Canyon project quarry north of Florence in Fremont County.

#### 4.2.5 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, agriculture water treatment, and other industrial applications. Natural Soda, Inc. operates the world's only nahcolite solution mine in Rio Blanco County. 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. The precipitate is further dried and prepared to produce commercial grades of sodium bicarbonate. Natural Soda completed an expansion project in 2013 to double the mine's production capacity to 250,000 tons per year. Production in 2015 totaled 207,731 tons, a 13.6% increase from the 182,787 tons produced in 2014 (Figure 4-12).

#### 4.2.6 SILICA

Sandstone is mined by Holcim (US) Inc. for use as a silica additive in their cement manufacturing plant in Florence. The sandstone is mined from the same area as the limestone and shale are mined to make the cement. CEMEX also mines sandstone as a cement additive at a mine in Boulder County. Well-rounded quartz sand from eolian deposits in the Colorado Springs area was mined by Colorado Silica Sand Co. in past years for silica sand. Most of this

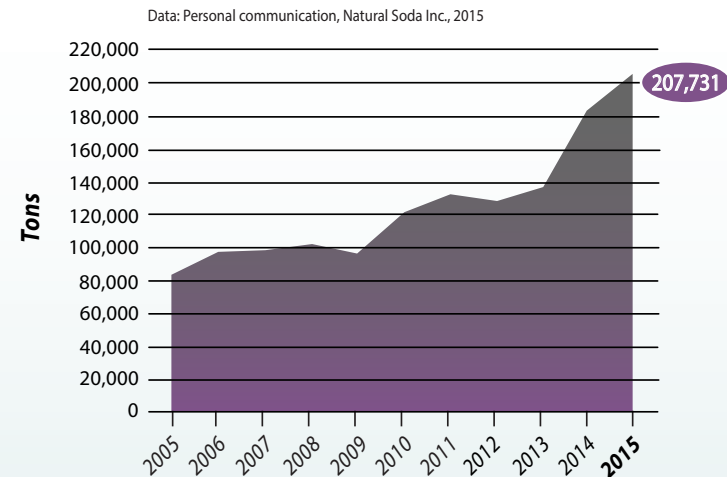


Figure 4-12. Sodium bicarbonate (nahcolite) production in Colorado, 2005–2015.

sand was used for filtration and water well packing purposes. The average price nationally for silica sand reported by the USGS for 2015 was \$86.93 per ton. Depending on the application and other factors, prices are highly variable.

Demand for proppant sand (also called “frac” sand), which is used in the hydraulic fracturing process to hold open rock fractures and facilitate the flow of oil and gas to wells, increased during the drilling boom of recent years. The decline of drilling activity has resulted in lower demand for frac sand resulting in a price decline from approximately \$90 per ton in 2014, to approximately \$70 per ton in June, 2016. According to the USGS, 71% of all silica sand usage in the U.S. is for hydraulic fracturing and well packing. Most proppant sand is currently mined in the midwest and southern states. Several sandstone formations in Colorado could be candidates for proppant sand mining. CGS initiated a field evaluation of sandstone formations and surficial sand deposits throughout the state for their potential suitability as proppant sand. The results from samples collected during this project are pending at the time of this writing.

#### 4.2.7 LIMESTONE, CALCIUM CARBONATE, AND LIME

Pete Lien & Sons mines high-purity limestone from deposits located in northern Colorado and southern Wyoming and grinds the rock into a calcium carbonate powder at their Livermore facility located in Larimer County. This material 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, manufacture of pharmaceuticals, fertilizer, filler, drilling fluids, and as an additive in glass manufacturing. Colorado Lime Co., a wholly owned



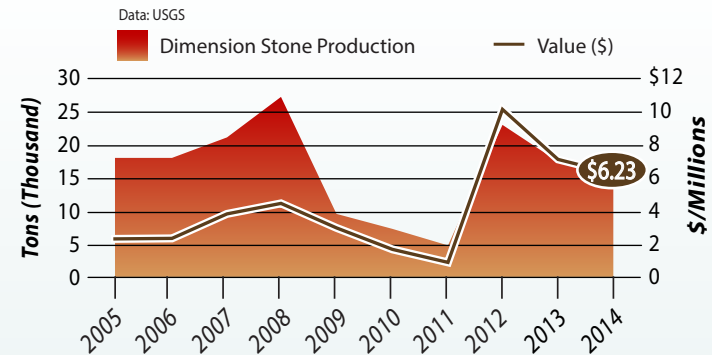
subsidiary of United States Lime & Minerals, Inc., operates the Monarch Quarry on the east side of Monarch Pass west of Salida. At this time, only crushed stone stockpiles are being processed from the Monarch Quarry. Facilities in Delta and Salida, process the high-purity limestone and produce ground calcium carbonate and screened limestone products for use mainly in coal mining and agriculture. Limestone and dolomite are also mined locally for crushed rock aggregate.

Lime is made by calcining (e.g. burning) high-purity limestone to form calcium oxide, commonly called quicklime. When water is mixed with lime, it forms hydrated or slaked lime (calcium hydroxide). Pete Lien & Sons produces hydrated lime at their Laporte plant near Fort Collins, CO. The hydrated lime is used primarily in water and wastewater treatment, well drilling applications, asphalt concrete treatment for anti-strip purposes, soil amendment processing, and other environmental/agricultural applications. Western Sugar Cooperative Inc.'s Fort Morgan plant operates a lime kiln which supplies the quick lime (converted to milk-of-lime with the addition of sweeteners) and carbon dioxide off-gas for the sugar purification system. Milk-of-lime is used in sugar processing to raise the pH of the product and to precipitate out impurities. According to data provided by the USGS, lime sold for an average of \$122.40 per ton nationally in 2014, up 1.1 % from the average price of \$121.10 in 2013. Data for 2015 were not available at the time of this report.

#### 4.2.8 DIMENSION STONE AND DECORATIVE STONE

Dimension stone is any visually appealing rock that is quarried, cut, or shaped into useful forms. In Colorado, sandstone, granite, marble, rhyolite, and alabaster (a form of gypsum) are quarried 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. It includes “river rock” (rounded cobbles), and “moss rock”, which is natural uncut boulders or cobbles with a thin veneer of colorful lichen (“moss”) in visually appealing patterns. In Colorado, various types of rock are mined locally for decorative use. **Figure 4-13** shows Colorado dimension stone production for the period from 2005-2014 based on USGS data.

Average annual prices and production of dimension stone are highly variable from year to year. Color, grain structure, and finish contribute to the dimension stone price and market. According to the USGS estimates, Colorado produced 17,300 metric tons of dimension stone in 2014 worth about \$6.2 Million. Colorado data for 2015 were unavailable at the time of this report. The average 2014 value for dimension stone was \$190 per metric ton, a 6% decrease from that of 2013 based on USGS estimates. Colorado was a minor producer while



**Figure 4-13. Production and product value of dimension stone in Colorado, 2005–2014.**

Texas, Indiana, Georgia, and Wisconsin were major U.S. producers. Estimated dimension stone production in the U.S. increased from 2.47 million tons in 2014 to 2.51 million tons in 2015. The majority of rock types produced in the U.S. in 2014 included limestone, granite, and sandstone. Colorado has many dimension stone and decorative stone producers. A cross-section of these companies along with a listing of their more significant products are summarized below:

*Arkins Park Stone* - Sandstone used for landscaping, building/home veneers, and rip-rap;

*Colorado Alabaster Supply* - Alabaster for sculpting;

*Colorado Flagstone* - Quartzite (hard sandstone) for building stone, veneers, landscaping, rip-rap, and flagstone applications;

*Colorado Rose Red Inc.* - Granite dimension stone used for building stone, monuments, memorials, countertops, landscape boulders, pavers, veneers (cladding), aggregate, and signs;

*Colorado Rose Sandstone* - Sandstone for building/home veneers, landscaping, pavers, curbstones, capstones, flagstone, and retaining walls;

*Colorado Stone Quarries* - Yule Marble dimension stone for memorials and building veneers;

*Monarch Stone Co.* - Dimension stone for building veneers, landscaping flagstone, decorative moss rock, and river rock;

*Schmidt Stone Quarry* - Rhyolite mainly used for building veneers;

*Siloam Stone* - Sandstone used for landscaping, building/home veneers, retaining walls, rip rap, moss rock, field stone, memorials, and monuments; and

*Stone Wholesale* - Sandstone for building/home veneers, decorative moss rock, and landscaping.

#### 4.2.9 PEAT

Peat is a natural material that consists of partially decayed and disintegrated plant material. It is often found in water-saturated environments and develops over thousands of years from the gradual decomposition of plant material under low oxygen conditions. Peat formation is generally controlled by topography and climate. It is mined for use in mixed fertilizers, potting soils, plant nurseries, golf course amendments, a filtration medium, and can be used as an energy source. The less decayed material, called sphagnum moss, is the highest quality peat. Hypnum moss, reed sedge, and humus are of decreasing quality due to increased decay of the original plant matter.

Colorado is a very minor producer of peat and most deposits occur at high elevations in wetlands areas (or areas that were formerly wetlands during wetter climates) near river or creek valleys. There are three active peat mining permits for operations located in Teller, Alamosa, and Park counties. The USGS estimated that the value of peat production in the conterminous U.S. was \$11.5 million in 2015. Consumption in the U.S. totaled 1.5 million tons in 2015. Minnesota and Florida are the leading producing states and most peat consumed in the U.S. is imported from Canada.

#### 4.2.10 GEM AND SPECIMEN MINERALS

Because of its diverse geological environments, Colorado is home to a variety of gem and specimen minerals. These include diamonds derived from kimberlite pipes in the Stateline district of Larimer County, aquamarine found in granite on Mount Antero in Chaffee County, amazonite in several areas within the Pikes Peak granitic batholith west of Colorado Springs, and rhodochrosite (Colorado's State Mineral) which is found in several places but most notably at the inactive Sweet Home Mine near Fairplay in Park County.

Other interesting gems and mineral specimens found in Colorado include turquoise mined near Cripple Creek in Teller County and a few other areas, peridot in the Badger Creek area of Park and Fremont counties, topaz, smoky quartz, and cryptocrystalline quartz. The Kelsey Lake diamond mine in northern Larimer County was a large commercial-scale operation; however, it has been idle since 2002. Most of the gem and specimen minerals are not consistently mined, nor are production and value consistently reported by the small operators. However, the USGS estimates that Colorado gem and specimen mineral operators produced minerals valued at \$447,000 for 2013, the latest year with available data.

The Sweet Home Mine sits below Red Amphitheatre in Park County. Photo CGS archive.

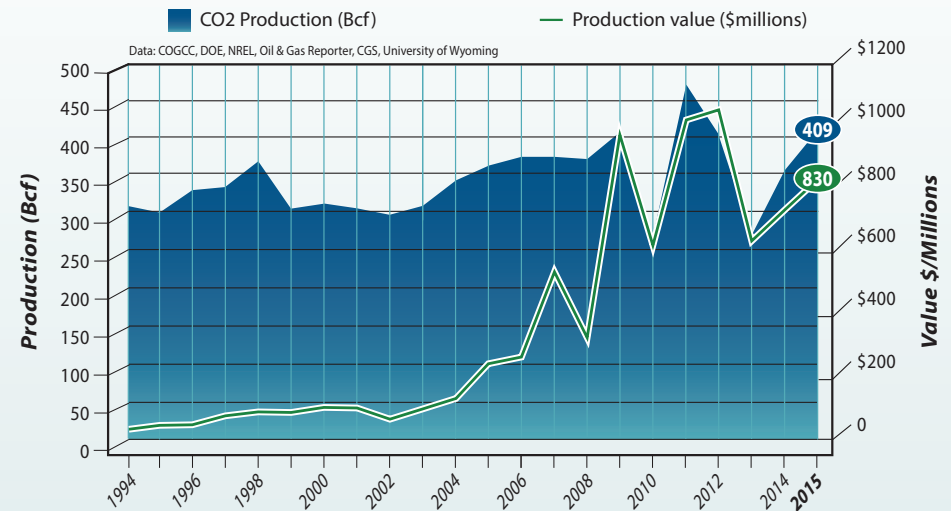


## 4.3.1. CARBON DIOXIDE

Naturally occurring carbon dioxide gas (CO<sub>2</sub>) is produced from the following areas in Colorado: McElmo Dome, Montezuma County; Sheep Mountain Field, Huerfano County; McCallum Field, Jackson County, and Rangely Field in Rio Blanco County. Kinder Morgan's McElmo Dome and Doe Canyon Deep units in Montezuma and Dolores counties 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). EOR is the implementation of various techniques for increasing the amount of crude oil that can be extracted from an oil field. Enhanced oil recovery is also called improved oil recovery or tertiary recovery (as opposed to primary and secondary recovery). In this process, CO<sub>2</sub> is injected into oil reservoirs to stimulate greater recovery. Other uses for the CO<sub>2</sub> extracted from the Colorado fields include welding gases, the manufacture of dry ice, and in the food and beverage industry. In 2015, Colorado CO<sub>2</sub> plants produced and sold 409 Bcf of CO<sub>2</sub> at an estimated average price of \$2.03 per Mcf for an estimated value of \$830 million. **Figure 4-14** shows Colorado's CO<sub>2</sub> production for the period 2005-2015.

## 4.3.2 HELIUM

Grade-A helium has been produced by DCP Midstream LLC at the Ladder Creek gas plant facility located in Cheyenne Wells, Cheyenne County in southeastern Colorado. According to records on file with the COGCC, the facility produced only a minimal amount of helium in 2014. No production is recorded for 2015. A new helium-producing facility built by Air Products Corp., next to the Doe Canyon CO<sub>2</sub> gas extraction plant operated by Kinder Morgan in Dolores County, went online in August 2015. The helium plant will extract approximately 230,000 Mcf per year of helium from the Doe Canyon CO<sub>2</sub> gas



**Figure 4-14. CO<sub>2</sub> production and production value in Colorado, 1994–2015.**

stream. The price for grade-A helium as calculated from an auction in 2015 was about \$104 per Mcf. Helium has numerous uses such as metallurgy, fiber optics, semiconductor manufacturing, magnetic resonance imaging (MRI), lifting high-altitude scientific research balloons, blimps and party balloons, breathing atmospheres for deep diving, unique blood gas medical mixtures, analytical chemistry, pressurizing and purging pipes and other critical equipment, leak detection, and other advanced applications.



## INFORMATION SOURCES and 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 and Karen Berry at the CGS for their technical reviews.

This project was funded through state severance tax funds.

Arkins Park Stone	<a href="http://www.arkinsparkstone.com/">http://www.arkinsparkstone.com/</a>
Azarga Uranium, investor presentation	<a href="http://azargauranium.com/wp-content/uploads/post/AZZ-IP-201601011.pdf">http://azargauranium.com/wp-content/uploads/post/AZZ-IP-201601011.pdf</a>
CEMEX	<a href="http://www.cemex.com/">http://www.cemex.com/</a>
Colorado Division of Reclamation, Mining, and Safety	<a href="http://mining.state.co.us/Pages/Home.aspx">http://mining.state.co.us/Pages/Home.aspx</a>
Colorado Division of Reclamation, Mining, and Safety, coal	<a href="http://mining.state.co.us/Pages/GISData.aspx">http://mining.state.co.us/Pages/GISData.aspx</a>
Colorado Geological Survey, Colorado Mineral and Energy Industry Activities 2014-2015	<a href="http://store.coloradogeologicalsurvey.org/product/colorado-mineral-and-energy-industry-activities-2014-15/">http://store.coloradogeologicalsurvey.org/product/colorado-mineral-and-energy-industry-activities-2014-15/</a>
Colorado Geological Survey, Atlas of Sand, Gravel, and Quarry Aggregate Resources	<a href="http://store.coloradogeologicalsurvey.org/product/atlas-of-sand-gravel-quarry-aggregate-resources-colorado-front-range-2">http://store.coloradogeologicalsurvey.org/product/atlas-of-sand-gravel-quarry-aggregate-resources-colorado-front-range-2</a>
Colorado Department of Local Affairs, tax distribution	<a href="https://www.colorado.gov/pacific/dola/direct-distribution-severance-tax-federal-mineral-lease">https://www.colorado.gov/pacific/dola/direct-distribution-severance-tax-federal-mineral-lease</a>
Colorado Department of Public Health and the Environment	<a href="https://www.colorado.gov/pacific/cdphe/news/Crested-Butte-streams">https://www.colorado.gov/pacific/cdphe/news/Crested-Butte-streams</a>
Colorado Department of Revenue	<a href="https://www.colorado.gov/pacific/revenue/annual-report">https://www.colorado.gov/pacific/revenue/annual-report</a>
Colorado Flagstone, Inc.	<a href="http://www.coloradoflagstone.com/">http://www.coloradoflagstone.com/</a>
Colorado Oil and Gas Conservation Commission	<a href="http://cogcc.state.co.us/data.html#/cogis">http://cogcc.state.co.us/data.html#/cogis</a>
Colorado Oil and Gas Conservation Commission, production data	<a href="http://cogcc.state.co.us/data4.html#/production">http://cogcc.state.co.us/data4.html#/production</a>
Colorado Rose Red	<a href="http://www.coloradorosered.com/">http://www.coloradorosered.com/</a>
Colorado Rose Sandstone Company	<a href="http://www.redsandstone.com/">http://www.redsandstone.com/</a>
Colorado Land Board, mineral revenues	<a href="http://drive.google.com/file/d/0BxRIvx2vXq4FUmV3V2tmclD5MU0/view">http://drive.google.com/file/d/0BxRIvx2vXq4FUmV3V2tmclD5MU0/view</a>
Colorado Stone Quarries	<a href="http://coloradostonequarries.com/">http://coloradostonequarries.com/</a>
Coeur Mining	2015 Annual Report
Dcp Midstream	<a href="http://www.dcpmidstream.com/">http://www.dcpmidstream.com/</a>
Denver Business Journal	<a href="http://www.bizjournals.com/denver/blog/earth_to_power/2016/02/oil-and-gas-job-losses-continue-to-hit-colorado.html">http://www.bizjournals.com/denver/blog/earth_to_power/2016/02/oil-and-gas-job-losses-continue-to-hit-colorado.html</a>
Denver Business Journal	<a href="http://www.bizjournals.com/denver/blog/earth_to_power/2016/03/anadarko-petroleum-to-lay-off-big-chunk-of-its.html">http://www.bizjournals.com/denver/blog/earth_to_power/2016/03/anadarko-petroleum-to-lay-off-big-chunk-of-its.html</a>
Denver Post	<a href="http://www.denverpost.com/2015/12/31/energy-oil-price-collapse-weighs-heavy-on-colorado-economy/">http://www.denverpost.com/2015/12/31/energy-oil-price-collapse-weighs-heavy-on-colorado-economy/</a>

Denver Post	<a href="http://www.denverpost.com/2015/12/10/looming-henderson-mine-closure-stokes-big-fears-in-clear-creek-county/">http://www.denverpost.com/2015/12/10/looming-henderson-mine-closure-stokes-big-fears-in-clear-creek-county/</a>
Energy Fuels	<a href="http://www.energyfuels.com/project/white-mesa-mill/">http://www.energyfuels.com/project/white-mesa-mill/</a>
Energy Fuels	<a href="http://www.energyfuels.com/">http://www.energyfuels.com/</a>
Fortune Minerals Limited	<a href="http://www.fortuneminerals.com/news/press-releases/press-release-details/2015/Fortune-Minerals-Receives-Notice-of-Default-Under-Prepay-Facility-and-Reaches-Agreement-in-Principle-to-Settle-Debt-Obligations/default.aspx">http://www.fortuneminerals.com/news/press-releases/press-release-details/2015/Fortune-Minerals-Receives-Notice-of-Default-Under-Prepay-Facility-and-Reaches-Agreement-in-Principle-to-Settle-Debt-Obligations/default.aspx</a>
Freeport-McMoRan Inc	<a href="http://2015-10-K">http://2015 10-K, Annual Report</a>
Gold Resource	<a href="http://goldresource.net/modern-uses-of-gold/">http://goldresource.net/modern-uses-of-gold/</a>
Gunnison Country Times	<a href="http://www.gunnisontimes.com/news/mine-co-acquires-mt-emmons-property">http://www.gunnisontimes.com/news/mine-co-acquires-mt-emmons-property</a>
Hecla Mining Company	2015 Annual Report
Hecla Mining Company	<a href="http://www.hecla-mining.com/san-juan/">http://www.hecla-mining.com/san-juan/</a>
Hecla Mining Company	<a href="http://ir.hecla-mining.com/Cache/1500081187.PDF?O=PDF&amp;T=&amp;Y=&amp;D=&amp;FID=1500081187&amp;iid=4130678">http://ir.hecla-mining.com/Cache/1500081187.PDF?O=PDF&amp;T=&amp;Y=&amp;D=&amp;FID=1500081187&amp;iid=4130678</a>
Henry Hub, natural gas prices in EIA	<a href="https://www.eia.gov/dnav/ng/hist/rngwhhdd.htm">https://www.eia.gov/dnav/ng/hist/rngwhhdd.htm</a>
Holcim US	<a href="http://www.holcim.us/">http://www.holcim.us/</a>
International Molybdenum Association	<a href="http://www.imoa.info/molybdenum-uses/molybdenum-uses.php">http://www.imoa.info/molybdenum-uses/molybdenum-uses.php</a>
Investing News Network	<a href="http://investingnews.com/daily/resource-investing/precious-metals-investing/gold-investing/barrick-newmont-anglogold-goldcorp-kinross-newcrest/">http://investingnews.com/daily/resource-investing/precious-metals-investing/gold-investing/barrick-newmont-anglogold-goldcorp-kinross-newcrest/</a>
Kinder Morgan, Doe Canyon Deep	<a href="http://www.kindermorgan.com/pages/business/co2/supply/supply_doeCanyon.aspx">http://www.kindermorgan.com/pages/business/co2/supply/supply_doeCanyon.aspx</a>
Kinross	2015 Annual Report
Leeds School of Business	<a href="http://www.colorado.edu/business/centers/business-research-division/research/51st-annual-colorado-business-economic-outlook">http://www.colorado.edu/business/centers/business-research-division/research/51st-annual-colorado-business-economic-outlook</a>
LKA International, Inc	<a href="http://www.lkagold.com/Golden-Wonder.php">http://www.lkagold.com/Golden-Wonder.php</a>
LKA International, Inc	<a href="http://www.lkagold.com/uploads/Drilling_Progress_3-15.pdf">http://www.lkagold.com/uploads/Drilling_Progress_3-15.pdf</a>
MiningFeeds	<a href="http://www.miningfeeds.com/2015/01/06/interview-with-uranium-expert-and-chairman-of-azarga-uranium/">http://www.miningfeeds.com/2015/01/06/interview-with-uranium-expert-and-chairman-of-azarga-uranium/</a>
Natural Soda Inc.	<a href="http://www.naturalsoda.com/">http://www.naturalsoda.com/</a>
Ouray County Plaindealer	<a href="http://www.ouraynews.com/articles/2016/02/25/ouray-mine-plans-try-again">http://www.ouraynews.com/articles/2016/02/25/ouray-mine-plans-try-again</a>
Portland Cement Association, fact sheet	<a href="http://www.cement.org/docs/default-source/ga-pdfs/cement-industry-by-state-2015/colorado.pdf?sfvrsn=2">http://www.cement.org/docs/default-source/ga-pdfs/cement-industry-by-state-2015/colorado.pdf?sfvrsn=2</a>
Pete Lien & Sons	<a href="http://www.petelien.com/">http://www.petelien.com/</a>
PR Newswire	<a href="http://www.prnewswire.com/news-releases/lka-gold-and-kinross-gold-usa-sign-exploration--option-agreement-30011926.html">http://www.prnewswire.com/news-releases/lka-gold-and-kinross-gold-usa-sign-exploration--option-agreement-30011926.html</a>
PR Newswire	<a href="http://www.prnewswire.com/news-releases/lka-gold-receives-golden-wonder-exploration-results-300218687.html">http://www.prnewswire.com/news-releases/lka-gold-receives-golden-wonder-exploration-results-300218687.html</a>
Rio Tinto	2015 Annual Production reports
San Juan Independent	<a href="http://sjindependent.org/report/fortune-minerals-defaults-on-revenue-silver-mine-debt/1121x">http://sjindependent.org/report/fortune-minerals-defaults-on-revenue-silver-mine-debt/1121x</a>
Schmidt Construction Company	<a href="http://schmidtconstruction.net/aggregate/">http://schmidtconstruction.net/aggregate/</a>
Siloam Stone	<a href="http://www.siloamstone.com/x">http://www.siloamstone.com/x</a>
SNL Metals and Mining	<a href="http://go.snl.com/SNL-Metals-Mining-World-Exploration-Trends-WET-2016-Report-Request-PR.html">http://go.snl.com/SNL-Metals-Mining-World-Exploration-Trends-WET-2016-Report-Request-PR.html</a>

SNL Metals and Mining	<a href="http://www.mch.cl/wp-content/uploads/sites/4/2016/04/Reporte-SNL-WET-2016_ingles.pdf">http://www.mch.cl/wp-content/uploads/sites/4/2016/04/Reporte-SNL-WET-2016_ingles.pdf</a> .
Stone Wholesale	<a href="http://www.stonewholesalecorp.com/">http://www.stonewholesalecorp.com/</a>
U.S. Energy Information Administration	<a href="http://www.eia.gov">http://www.eia.gov</a>
U.S. Energy Information Administration, Colorado data	<a href="https://www.eia.gov/state/analysis.cfm?sid=CO">https://www.eia.gov/state/analysis.cfm?sid=CO</a>
U.S. Energy Information Administration, oil and natural gas reserves	<a href="http://www.eia.gov/naturalgas/crudeoilreserves/">http://www.eia.gov/naturalgas/crudeoilreserves/</a>
U.S. Energy Information Administration, natural gas production	<a href="https://www.eia.gov/dnav/ng/hist/n9070us2M.htm">https://www.eia.gov/dnav/ng/hist/n9070us2M.htm</a>
U.S. Energy Information Administration, coal	<a href="http://www.eia.gov/coal">http://www.eia.gov/coal</a>
U.S. Department of the Interior, Office of Natural Resources Revenue	<a href="http://www.onrr.gov/About/production-data.htm">http://www.onrr.gov/About/production-data.htm</a>
USGS, Front Range resources fact sheet	<a href="https://pubs.usgs.gov/fs/fs-0119-98/fs-0119-98po.pdf">https://pubs.usgs.gov/fs/fs-0119-98/fs-0119-98po.pdf</a>
USGS, frac sand	<a href="http://pubs.usgs.gov/of/2015/1107/pdf/ofr20151107.pdf">http://pubs.usgs.gov/of/2015/1107/pdf/ofr20151107.pdf</a>
USGS, Mancos Shale	<a href="https://www.usgs.gov/news/usgs-estimates-66-trillion-cubic-feet-natural-gas-colorado-s-mancos-shale-formation">https://www.usgs.gov/news/usgs-estimates-66-trillion-cubic-feet-natural-gas-colorado-s-mancos-shale-formation</a>
USGS, Green River Formation	<a href="https://pubs.usgs.gov/fs/2012/3145/FS12-3145.pdf">https://pubs.usgs.gov/fs/2012/3145/FS12-3145.pdf</a>
USGS, peat information	<a href="http://minerals.usgs.gov/minerals/pubs/commodity/peat/">http://minerals.usgs.gov/minerals/pubs/commodity/peat/</a>
USGS, dimension stone information	<a href="http://minerals.usgs.gov/minerals/pubs/commodity/stone_dimension/">http://minerals.usgs.gov/minerals/pubs/commodity/stone_dimension/</a>
USGS, lime information	<a href="http://minerals.usgs.gov/minerals/pubs/commodity/lime/">http://minerals.usgs.gov/minerals/pubs/commodity/lime/</a>
USGS, 2005 mineral commodity summary	<a href="http://minerals.usgs.gov/minerals/pubs/mcs/2005/mcs2005.pdf">http://minerals.usgs.gov/minerals/pubs/mcs/2005/mcs2005.pdf</a>
USGS, 2016 mineral commodity summary	<a href="https://pubs.er.usgs.gov/publication/70170140">https://pubs.er.usgs.gov/publication/70170140</a>
USGS, 2015 mineral commodity summary	<a href="http://minerals.usgs.gov/minerals/pubs/mcs/2015/mcs2015.pdf">http://minerals.usgs.gov/minerals/pubs/mcs/2015/mcs2015.pdf</a>
USGS, 2016 gold mineral commodity summary	<a href="http://minerals.usgs.gov/minerals/pubs/commodity/gold/mcs-2016-gold.pdf">http://minerals.usgs.gov/minerals/pubs/commodity/gold/mcs-2016-gold.pdf</a>
USGS, 2016 silver mineral commodity summary	<a href="http://http://minerals.usgs.gov/minerals/pubs/commodity/silver/mcs-2016-silve.pdf">http://http://minerals.usgs.gov/minerals/pubs/commodity/silver/mcs-2016-silve.pdf</a>
USGS, Sand and gravel	<a href="http://minerals.usgs.gov/minerals/pubs/commodity/sand_&amp;_gravel_construction/mcs-2016-sandc.pdf">http://minerals.usgs.gov/minerals/pubs/commodity/sand_&amp;_gravel_construction/mcs-2016-sandc.pdf</a>
United States Lime & Minerals Inc., annual report and 10-K	<a href="http://www.uslm.com/pdfs/USLM_2015_Annual_Report.pdf">http://www.uslm.com/pdfs/USLM_2015_Annual_Report.pdf</a>
Uranium Energy Corp	<a href="http://www.uraniumenergy.com/projects/colorado/">http://www.uraniumenergy.com/projects/colorado/</a>
U.S. Energy Information Administration, 2015 production report	<a href="https://www.eia.gov/uranium/production/annual/pdf/dupr.pdf">https://www.eia.gov/uranium/production/annual/pdf/dupr.pdf</a>
U.S. Rare Earths	<a href="http://investor.usrareearths.com/releasedetail.cfm?ReleaseID=925290">http://investor.usrareearths.com/releasedetail.cfm?ReleaseID=925290</a>
Ux Consulting Co	<a href="https://www.uxc.com/p/prices/UxCPriceChart.aspx?chart=spot-u3o8-2yr">https://www.uxc.com/p/prices/UxCPriceChart.aspx?chart=spot-u3o8-2yr</a>
Western Uranium Corporation	<a href="http://www.blackrangeminerals.com/statement/WUC_SEDAR_12_31_15_Re-file_6_21_16.pdf">http://www.blackrangeminerals.com/statement/WUC_SEDAR_12_31_15_Re-file_6_21_16.pdf</a>
World Nuclear News, uranium markets	<a href="http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-markets.aspx">http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-markets.aspx</a>
World Nuclear News	<a href="http://www.world-nuclear-news.org/UF-US-uranium-production-falls-in-2015-2302167.html">http://www.world-nuclear-news.org/UF-US-uranium-production-falls-in-2015-2302167.html</a>
World Nuclear Association	<a href="http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx">http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx</a>
World Nuclear Association	<a href="http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx">http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx</a>
World Nuclear Association	<a href="http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/appendices/us-nuclear-fuel-cycle-appendix-1-us-uranium-mining.aspx">http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/appendices/us-nuclear-fuel-cycle-appendix-1-us-uranium-mining.aspx</a>

Zephyr Minerals Ltd.

[http://media.wix.com/ugd/2f57bf\\_f7d300bbe77c4f8abe139eddb34f166c.pdf](http://media.wix.com/ugd/2f57bf_f7d300bbe77c4f8abe139eddb34f166c.pdf)

Zephyr Minerals Ltd.

<http://www.zephyrminerals.com/#!ni-43-101-report/yez4r>

Zephyr Minerals Ltd.

[http://media.wix.com/ugd/2f57bf\\_d60fd5efbcaf4f219d336b300c1ee474.pdf](http://media.wix.com/ugd/2f57bf_d60fd5efbcaf4f219d336b300c1ee474.pdf)

Zephyr Minerals Ltd.

[http://media.wix.com/ugd/2f57bf\\_2826d9408ed7405884419aacb57bb16b.pdf](http://media.wix.com/ugd/2f57bf_2826d9408ed7405884419aacb57bb16b.pdf)



