INFORMATION SERIES 70

Colorado Mineral and Mineral Fuel Activity, 2004

By
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Colorado Geological Survey • Division of Minerals and Geology • Department of Natural Resources • Denver, Colorado • 2005

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Cover Figure Captions

From the 12:00 o'clock position and going clockwise:

Sorted and screened Colorado River gravel, which because of its hardness, shape, and durability can be used for a multitude of construction purposes (photo by Beth Widmann)

Sign at the abandoned Uranium Drive-In Theatre in Naturita, Colo.—a former uranium boomtown that is enjoying a mild resurgence because of increased uranium mining in the region (photo by John Keller).

Blending hall at the Holcim cement plant, Florence, Colo. The stack is 32 feet high, 90 feet wide, and 300 feet long, and consists of the raw materials, limestone and shale, needed to make cement (photo by Beth Widmann).

Longs Peak looms in the background as pumps extract oil and gas from the Wattenberg field, Boulder and Weld County, Colo. (photo courtesy of Colorado Oil and Gas Conservation Commission).

Load-out facility and storage bins for coal, West Elk Mine, Gunnison County (photo by Chris Carroll)

CONTENTS

EXECUTIVE SUMMARY

The Colorado mineral and mineral fuel industries have enjoyed another year of spectacular growth; not only has production increased dramatically for most commodities, but prices for mineral and petroleum commodities have also increased. Employment levels have increased sharply.

The Colorado Geological Survey (CGS) estimates the total value of 2004 mineral and mineral fuel production in Colorado to be **$8.502** billion—a 27.7 percent increase from the revised* 2003 total value of $6.655 billion (fig. 1, fig. 2, and table 1).

Mineral fuel, carbon dioxide, and nonfuel mineral production values for 2004 are estimated at:

- **Oil—$849 million**
- **Natural gas—$5,773 million**
- **Carbon dioxide—$129 million**
- **Coal—$800 million**
- **Nonfuel minerals—$949 million**
- **Uranium—$2 million**

The total estimated value of oil, natural gas, and carbon dioxide production in 2004 was $6.751 billion, which is up 35 percent from the 2003 value of $5.250 billion. Colorado natural gas and oil production and their respective prices increased strongly during 2003. The production and price for carbon dioxide climbed during the year, increasing the value of production from $98 million in 2003 to $129 million in 2004—a 32 percent increase. Oil, gas, and carbon dioxide average prices are obtained from the Colorado Oil and Gas Conservation Commission.

Coal production increased from the 2003 level of 35.9 million tons to a record 40.0 million tons in 2004. The average coal price on federal leases for 2004 is estimated at $18.09 per ton, down from $19.59 in 2003. The average coal price is obtained from Colorado Department of Local Affairs, which receives sales information from the federal Minerals Management Service; this price reflects both contract and spot sales of coal from federal leases, which are about 75 percent of the coal produced in Colorado. Spot prices for coal in Colorado for 2004 averaged about $29 per ton according to U.S. Department of Energy/Energy Information Agency data. CGS estimates the average price for all coal produced in Colorado to be $20 per ton. The value of Colorado coal production is estimated at $800 million—up 14 percent from the revised* 2003 value of $702 million.

The CGS estimates the value of the 2004 nonfuel mineral production to be $949 million—a 35 percent increase from the 2003 value of $702 million. Price increases for both molybdenum and gold were a factor in the increase of non-fuel mineral value.

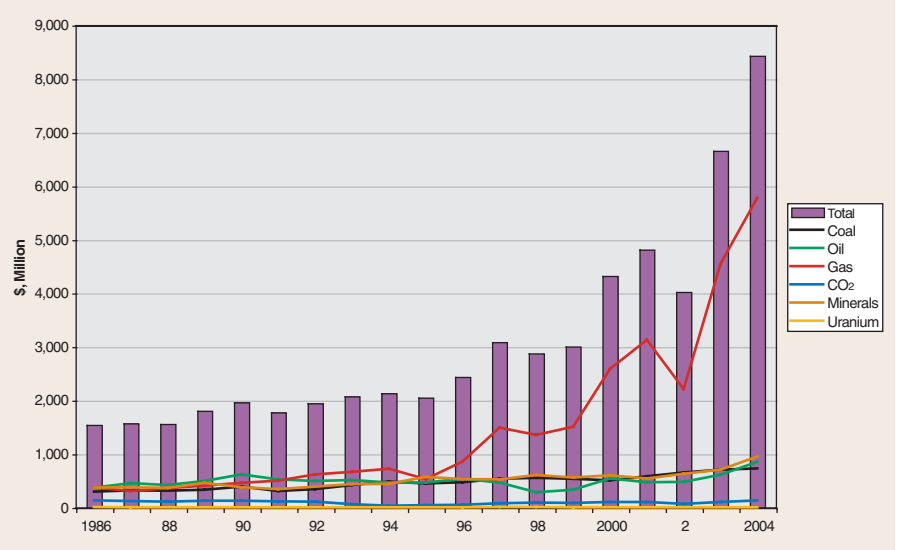

Figure 1: Colorado Mineral and Mineral Fuel Production Value, 1986–2004

Uranium production value in 2004 increased ten-fold from $0.2 million in 2003 to $2 million in 2004. Uranium prices are expected to continue to rise in 2005, which will most likely result in increased production in Colorado. Several new mines are scheduled to open on the Western Slope.

Taxes and royalties from mineral and mineral fuel production flow directly back to the State of Colorado and local governments. The combined total of federal mineral lease revenues, state severance taxes, Colorado State Land Board mineral royalties and rentals, and county property taxes on mineral properties is $384 million.

* Estimated production and values are obtained from other state agencies and federal agencies. Sources of data are explained in the appropriate section in the following chapters. The 2003 production value is revised from the published value of $6,051 million (Colorado Geological Survey Information Series 69, *Mineral and Mineral Fuel Activity, 2003.*

Table 1: Colorado mineral and mineral fuel production and value, 2003 and 2004

2004	Volume Produced	Volume Sold	Unit Value	Sold Value (Million USD)	Change in value from 2003
Hydrocarbon and Carbon Dioxide Production Statistics[1]					
Natural gas (Bcf)	1,073 Bcf	1,042 Bcf	$5.54/Mcf	$5,772	+27%
Crude oil (MMbo)	22.1 MMbo	21.9 MMbo	$38.78/bbl	$849	+40%
Carbon dioxide (Bcf)	341 Bcf	340 Bcf	$0.38/Mcf	$129	+32%
Estimated Total Value of Hydrocarbons and Carbon Dioxide				$6,750	+29%
Coal Production Statistics[2]					
Estimated Total Value of Coal Production	40 Mst	– –	$20/st	$800	+14%
Mineral Production Statistics[3,4]					
Gold	343,350 oz	– –	– –	$111	+5%
Silver	199,057 oz	– –	$6.67	$1.3	+92%
Molybdenum	27.5 million lbs	– –	$12.65	$348	+170%
Uranium	112,803 lbs	– –	$18.55	$2.1	+600%
Vanadium	281,900 lbs	– –	$5.28	$1.5	+650%
Industrial Minerals	– –	– –	– –	$488	+4%
Estimated Total Value of Non-fuel and Uranium Minerals Production				$952	+36%
Estimated Total Value of all Mineral and Mineral Fuel Production in Colorado				**$8,502**	**+28%**

2003	Volume Produced	Volume Sold	Unit Value	Sold Value (Million USD)	Change in value from 2002
Hydrocarbon and Carbon Dioxide Production Statistics[1]					
Natural gas (Bcf)	1,032 Bcf	1,001 Bcf	$4.54/Mcf	$4,545	+106%
Crude oil (MMbo)	21.4 MMbo	21.3 MMbo	$28.51/bbl	$607	+28%
Carbon dioxide (Bcf)	307 Bcf	307 Bcf	$0.32/Mcf	$98	+58%
Estimated Total Value of Hydrocarbons and Carbon Dioxide				$5,250	+91%
Coal Production Statistics[2]					
Estimated Total Value of Coal Production	35.9 Mst	– –	$19.59/st	$703	+8.3%
Mineral Production Statistics[3,4]					
Gold	307,864 oz	– –	– –	$105	+37%
Silver	142,200 oz	– –	$4.87	$0.7	+34%
Molybdenum	22.2 million lbs	– –	$5.79	$129	+37%
Uranium	25,891 lbs	– –	$11.55	$0.3	– –
Vanadium	89,833 lbs	– –	$2.21	$0.2	– –
Industrial Minerals	– –	– –	– –	$467	-6%
Estimated Total Value of Non-fuel and Uranium Minerals Production				$702	+5%
Estimated Total Value of all Mineral and Mineral Fuel Production in Colorado				**$6,655**	**+79%**

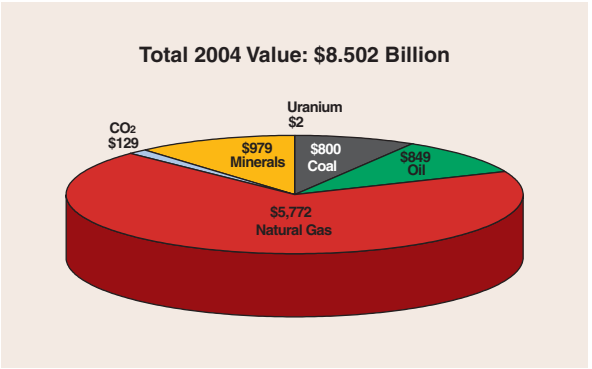

Figure 2: Mineral and mineral fuel production value ($million) by sector, 2004

Table Sources: [1]Colorado Oil and Gas Commission, http://oil-gas.state.co.us/; [2]Colorado Department of Local Affairs, http://www.dola.state.co.us/LGS/FA/EMIA/miner/MinerWebTables.pdf; [3]U.S. Geological Survey Minerals Information, http://minerals.usgs.gov/minerals/pubs/mcs/; [4]Company reports and press releases.

Abbreviations: Bcf—billion cubic feet; Mcf—million cubic feet; MMbo—million barrels; bbl—barrels; Mst—million short tons; st—short tons; oz—ounces; lbs—pounds.

INTRODUCTION AND ECONOMIC FACTORS

The mineral and mineral fuel industries provide the essential elements of modern day life from gasoline for our cars; steel for our buildings, trucks, airplanes, and bridges; to copper for wires and electrical parts; to gravel for our roads. Every day, every citizen, in some way, touches or uses products provided by these industries. The Mineral Information Institute estimates that the average American will use 3.6 million pounds of minerals, metals, and fuels during an average life span of 77 years—that is over 46,000 pounds of materials every year for every American (fig. 3).

The mineral and mineral fuel industries in Colorado produce a wide variety of materials essential to our daily lives; coal provides electricity, natural gas heats our homes, molybdenum hardens our steel. Sand and gravel is necessary for our homes, offices, roads, driveways, and many other uses.

The Colorado mineral and mineral fuel industries have enjoyed another year of spectacular growth; not only has production increased dramatically for most commodities, but prices for most mineral and petroleum commodities have also increased. Employment levels have increased sharply.

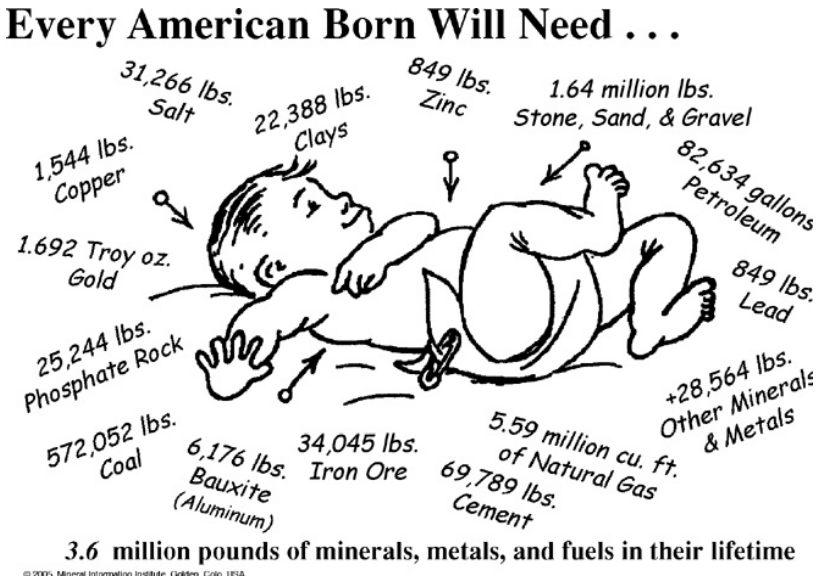

Figure 3: Mineral needs of the average American (Courtesy of the Mineral Information Institute).

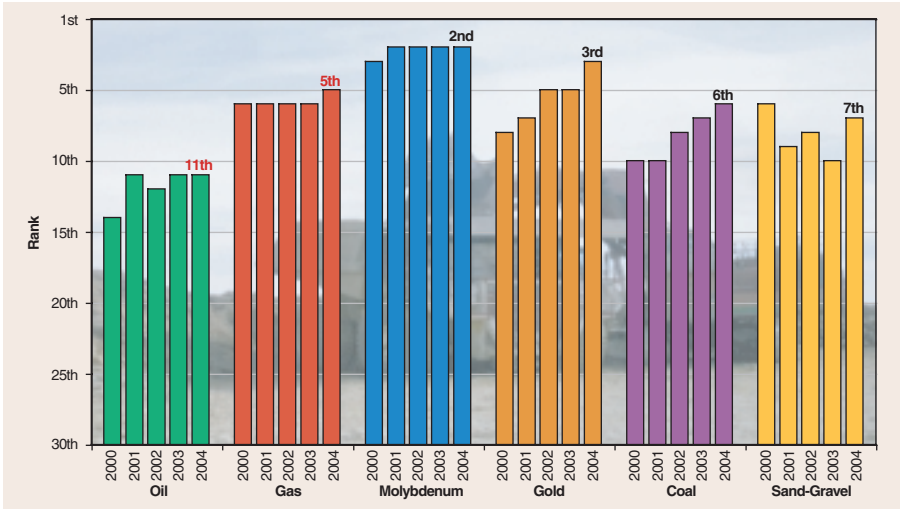

Figure 4: Colorado's ranking among all states in selected mineral and mineral fuel commodity production (U.S. Geological Survey)

The Colorado Geological Survey (CGS) estimates the total value of 2004 mineral and mineral fuel production in Colorado to be $8,502 million—a 27.7 percent increase from the (revised*) 2003 total value of $ 6,655 million (fig. 1, fig. 2, and table 1).

Marked increases in natural gas, molybdenum, gold, coal, and sand and gravel production have raised Colorado's national rankings in these categories (fig. 4).

The value of Colorado's mineral and mineral fuel production is realized in many ways including employment, taxes, and royalties that flow back to state and local governments. The value of Colorado's share of federal mineral royalties in 2004 is $89.9 million—a 42 percent increase from the 2003 value of $63.1 million. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (fig. 5).

Severance taxes are state taxes that are collected on the production of oil, gas, coal and certain minerals. According to Colorado law, 50 percent of the severance tax revenue flows to local governments and 50 percent flows into a state trust fund to "replace" depleted natural resources and to complete water projects. Legislation passed in 1996 allows some of the state share of severance tax to be used by agencies within the Department of Natural Resources that promote and regulate the mineral and mineral fuel industries. Severance tax collections in fiscal

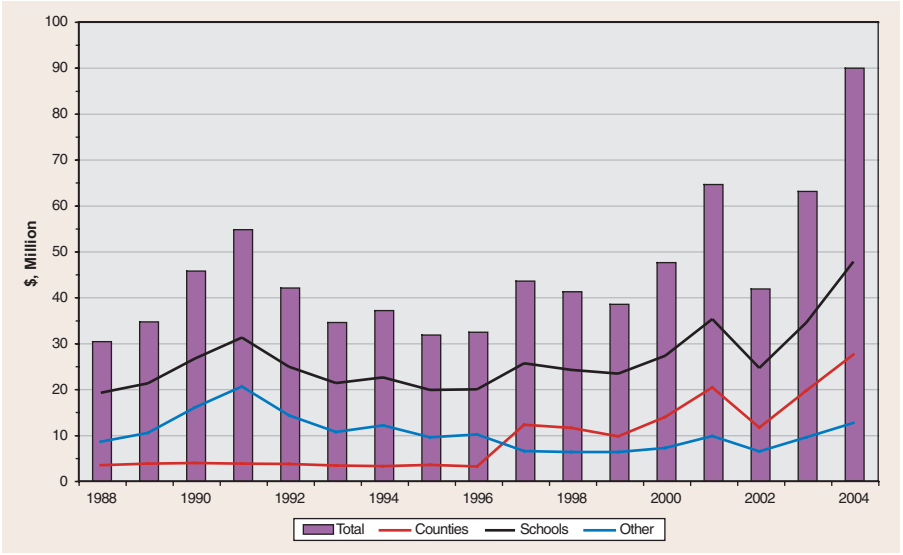

Figure 5: Federal mineral lease revenue and distribution

year 2004 were $115.8 million—up 250 percent from the 2003 severance tax collection of $32.4 million (fig. 6).

Estimated property taxes paid in 2004 to the counties from mineral and mineral fuel properties totaled $153 million (fig. 7). All Colorado counties except Denver County receive revenue from mineral related property taxes.

In the fiscal year ending on June 30, 2004, the Colorado State Land Board received $25.8 million from mineral royalties, bonuses, and rentals on state owned land. The state owns over 4 million acres of mineral land and the revenues from these lands go to the Permanent Fund. Interest from this fund is distributed by the School Finance Act to the school districts of Colorado (fig. 8).

The Colorado Department of Labor and Employment tracks employment trends for the state. Employment statistics for the oil and gas extraction industry are included in their "Natural Resources and Mining Supersector" along with employment data for the coal, non-fuel minerals, and logging industries. This supersector grew 11.5 percent (from 12,200 to 13,600) between 2000 and the end of 2004 (fig. 9). The *Colorado Business Economic Outlook Forum* annual report for 2005 states that about one-third of the employees in this supersector work in each of the following areas: oil and gas extraction, mining, and support activities. The four percent growth in employment from 13,200 in 2003 to 13,600 in 2004 has resulted in a new ten-year high.

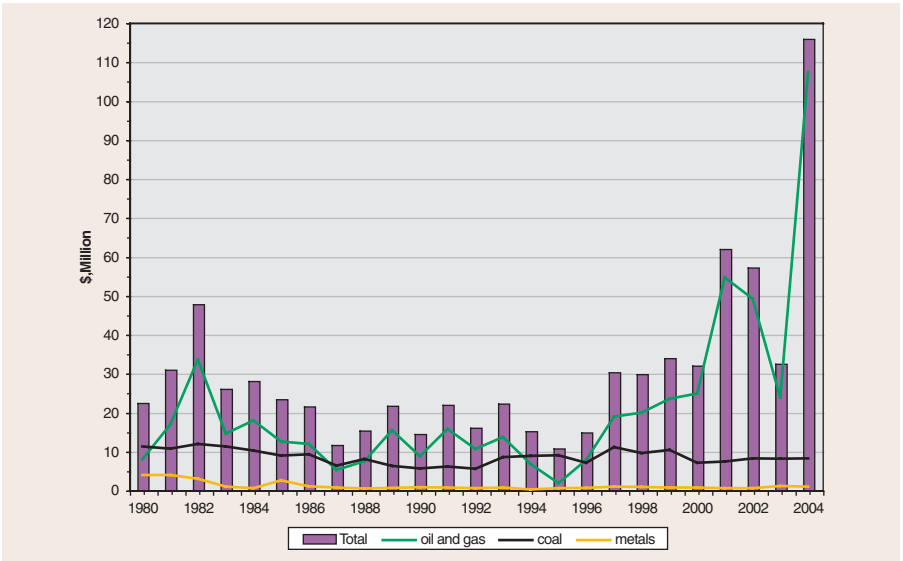

Figure 6: Colorado mineral severance tax revenue

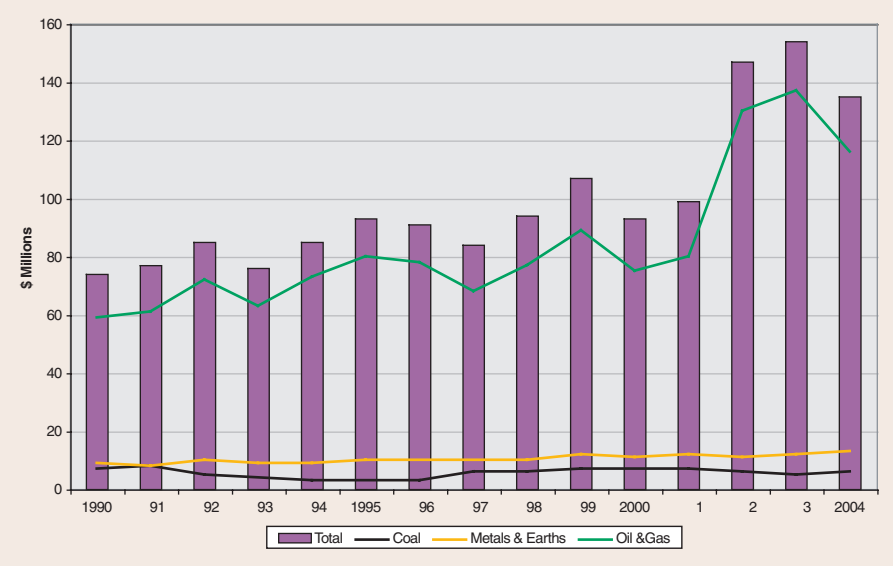

Figure 7: Property tax collections from Colorado mineral properties

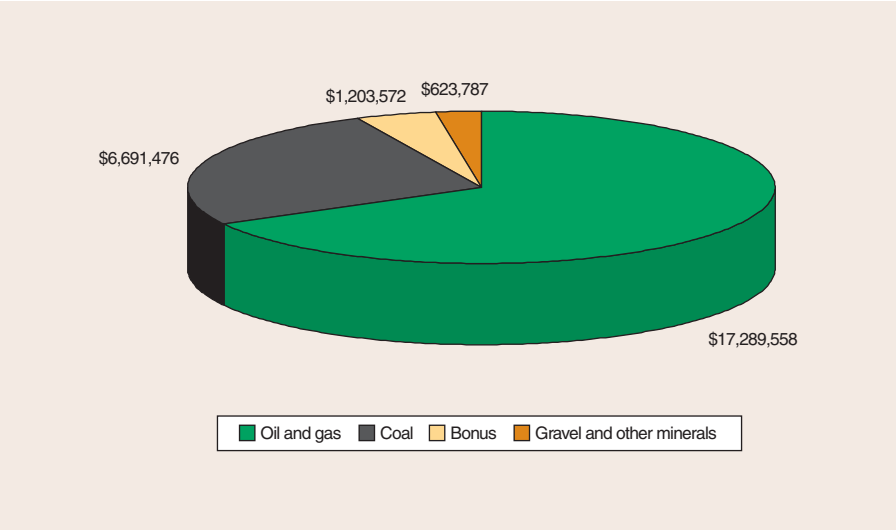

Figure 8: Colorado State Land Board Mineral Revenues, July 1, 2003–June 30, 2004

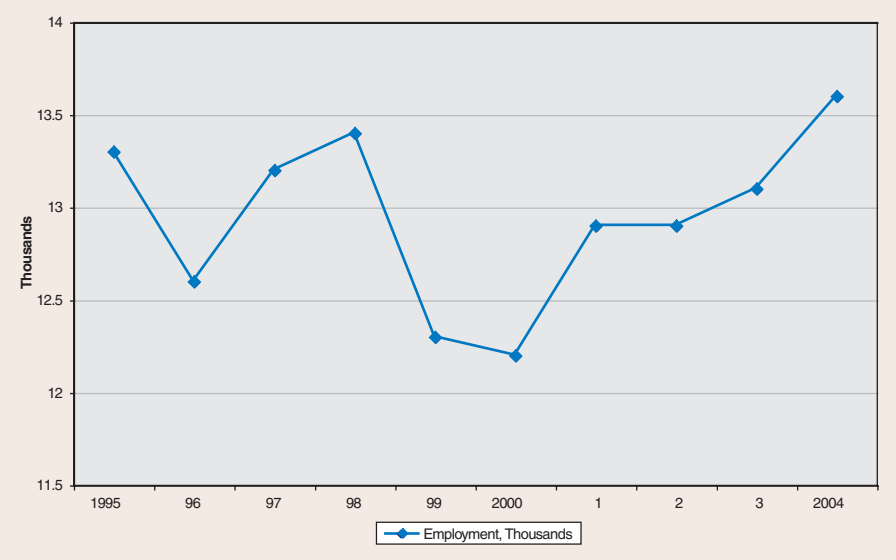

Figure 9: Colorado mineral and mineral fuel employment

OIL, NATURAL GAS, AND CARBON DIOXIDE

Summary

The Rocky Mountain region, and in particular Colorado, continues to experience a boom in its energy sector. Although briefly interrupted in 2002, this boom is currently in its fifth year and is showing no sign of slowing down in the near future (fig. 10). The energy markets have also continued to experience a much greater than normal volatility in commodity prices during 2004. The combination of price volatility and growing demand has adversely impacted all business sectors in the state with higher energy costs.

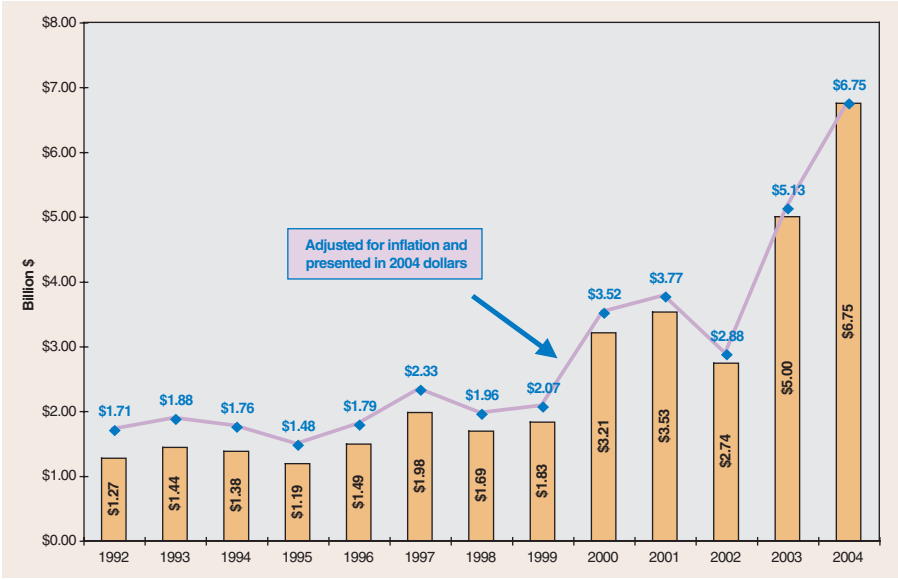

Figure 10: Annual production value for oil, natural gas, and carbon dioxide in Colorado, 1992–2004. Bar graph shows actual value for the corresponding year. The line graph shows value in constant 2004 dollars (Colorado Oil and Gas Conservation Commission [COGCC]).

The total value of oil, gas, and carbon dioxide production in 2004 is estimated at $6.75 billion, representing a 35 percent increase over the 2003 value of $5.0 billion. This increase in value resulted from a significant increase in both production volume and commodity price. When the value is adjusted for inflation and presented in 2004 dollars, it is apparent that the value of oil, gas, and carbon dioxide production in Colorado has experienced very real gains since the 1990s.

Commodity Prices

Oil and natural gas prices for Colorado are tracked by, and made available by, the Colorado Oil and Gas Conservation Commission (COGCC) via their website. Colorado's so-called "oil price" is actually a computed oil price composite index. This weighted index is calculated based on the geographic quadrant of the state in which the production occurs (NW, SW, NE, or SE) and the particular refinery that is purchasing the production (Chevron Texaco, Shell, or Valero).

Colorado Weighted Average Oil Price Composite Index =
0.35 NW (Chevron Texaco) + 0.05 SW (Shell) + 0.40 NE (Valero) + 0.20 SE (Valero)

The state's oil price index has shown strong growth in recent years, particularly since the beginning of 2002 where oil prices have increased more than two-fold from about $17 per barrel to the mid-$40s by the end of 2004 (fig. 11). West Texas Intermediate (WTI) is a type of crude oil used as a benchmark in U.S. oil pricing and is the underlying commodity of the New York Mercantile Exchange's oil futures. WTI is very light and very sweet (low-sulfur), which typically causes it to trade at a dollar or two premium compared to other benchmark crude oils (for example, Brent and OPEC market basket). Colorado crude oil historically trades at a price above that of WTI, averaging about $0.70 per barrel more for Colorado crude than WTI for the last three years.

As with Colorado's oil index, the often-quoted "gas price" is actually a computed composite index. This weighted index is based on the geographic area of the state in which the production occurs and the pipeline infrastructure that it will supply. The Northwest Pipeline System is a 4,000-mile bi-directional transmission system crossing through western Colorado and provides access to western Canada, U.S. Rocky Mountains and San Juan Basin gas supplies. El Paso Natural Gas has more than 17,000 miles of pipeline that connects gas from Colorado's portion of the San Juan Basin to markets principally in California. Colorado Interstate Gas extends from producing areas in the Rocky Mountains and Anadarko Basin to the Colorado Front Range with multiple interconnects serving the Midwest, the Southwest, California, and the Pacific Northwest.

Colorado Weighted Average Gas Price Composite Index =
0.20 RM (NW P/L) + 0.50 SJB (El Paso) + 0.30 Rockies (CIG)

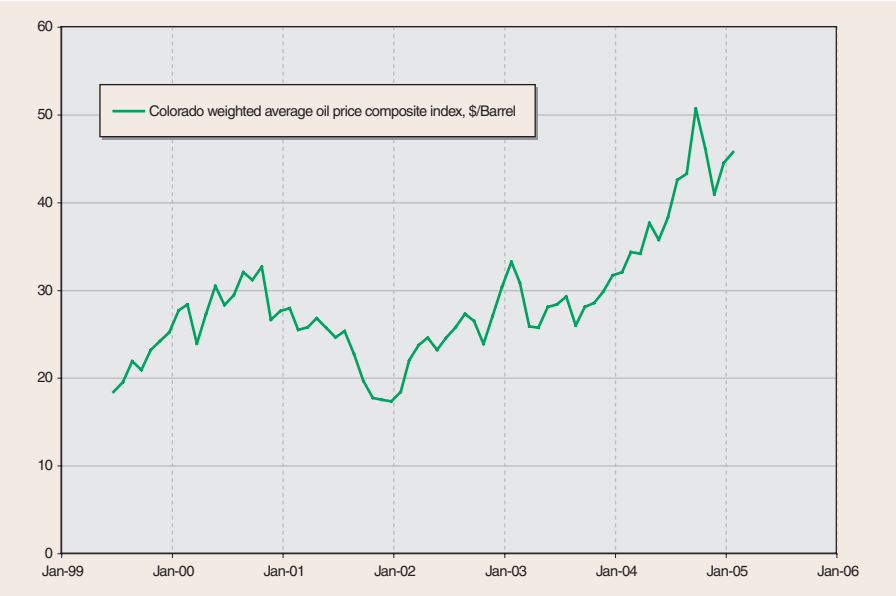

Figure 11: Colorado weighted average oil price composite index; monthly data for July 1999–March 2005 (COGCC).

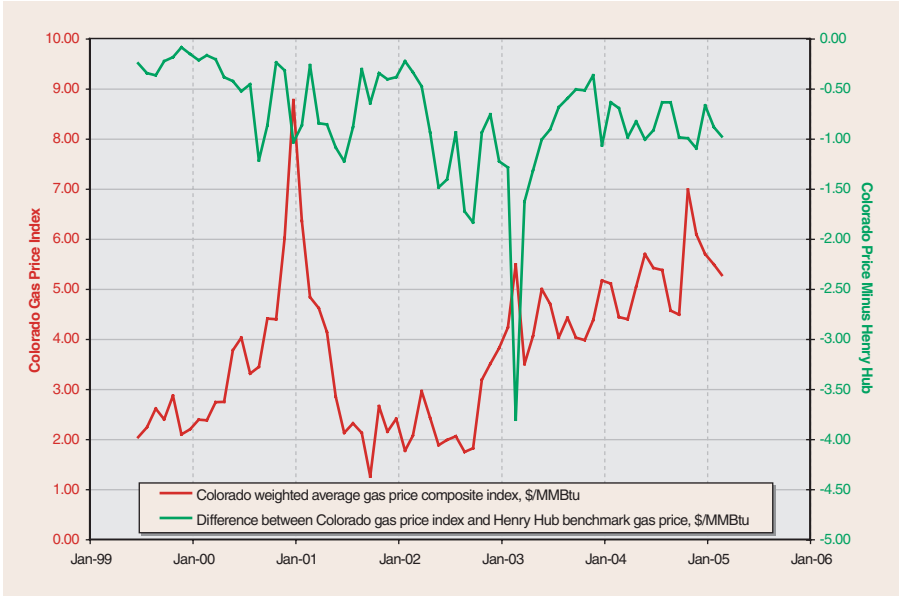

Figure 12: Colorado weighted average gas price composite index and Henry Hub basis differential; monthly data July 1999–March 2005 (COGCC).

The state's gas index has shown strong recovery in recent years. Although there is considerable price fluctuation, the average gas price has increased from about $4.00 per million Btu (British thermal units) to more than $5.50 in the last two years. This represents an overall increase of almost 40 percent since the beginning of 2003, and nearly a three-fold increase over the average price of $2.13 per million Btu during the 2001–2003 period (fig. 12).

The Henry Hub in southern Louisiana is the principal pricing point for U.S. natural gas markets. The New York Mercantile Exchange natural gas futures contract specifies the hub as its delivery point. The volatility of natural gas prices has given rise to a basis market that is quoted as a differential to the price of the Henry Hub natural gas futures contract; hence, the inevitable comparison between local natural gas prices and those at Henry Hub. Colorado natural gas historically brings a lower price than that at Henry Hub due to the less than adequate pipeline infrastructure to move Rockies' gas to broader markets, particularly to the densely populated eastern U.S. Thus, the Colorado basis differential is shown as a *negative* value (fig. 12).

The opening of the Kern River pipeline expansion in mid-2003 provided Colorado operators (among others in the Rockies) the opportunity to compete with markets in California. Not only is this increased competition reflected in stronger gas prices for Colorado, but also in an adjustment to the local basis differential (fig. 12). Prior to the opening of the Kern River expansion, the Colorado differential had grown from an average of -$0.25 in mid-1999 to an average of -$1.25 in early 2003, with monthly fluctuations as high as -$3.82 per million Btu. That is, Colorado gas prices were falling relative to those at Henry Hub because more gas was being produced in the state than there was pipeline capacity to transport it to other markets. The post-Kern River period saw a significant tightening in the gas market, yielding an immediate adjustment in the basis differential of about -$0.50 per million Btu in mid-2003—that is, more favorable prices for Colorado producers. Because of this correction, the post-Kern River period has been characterized by an average basis differential in the range of -$0.70 to -$1.00 per million Btu.

Oil and Gas Production Volume and Value

Since 2002, the energy industry has been benefiting from a "win-win" scenario—production of oil and natural gas has been on the rise *and* prices for those commodities have been increasing at spectacular rates. As a result, the combined value of oil and natural gas production in Colorado hit an all time high in 2004 of $6.6 billion. Of this value, 88 percent (or $5.8 billion) is due to the sale of natural gas. For the second consecutive year, natural gas production in Colorado has exceeded one trillion cubic feet (Tcf) (fig. 13). Natural gas production in 2004 was 1.07 Tcf and represented a four percent increase over the 1.03 Tcf produced in 2003. Since separate reporting for coalbed methane began in 1990, coalbed methane production has grown to

represent about one-half of the state's natural gas production. In 2004, coalbed methane production was 501 billion cubic feet (Bcf) which represented a 2.5 percent decline from the peak of 514 Bcf reported in 2003.

Oil production in Colorado began to precipitously decline in 1995, hitting a low of 19.1 million barrels in 2000. Since then strong commodity prices have driven a reversal in this downward trend resulting in a gradual (but steady) increase in oil production over the last four years (fig. 13). Oil production in 2004 was 22.1 million barrels and represented a 3.2 percent increase over the 21.4 million barrels produced in 2003.

Average monthly oil production has been gradually increasing about 3 percent per year since mid-1999 from 1.6 million barrels per month to 1.85 million barrels per month by late 2004 (fig. 14). By contrast, the value of that production each month has gone from $30 million to about $80 million per month during the same period, representing more than a 2.5-fold increase in the value of the state's oil production. Although this dramatic increase in value is due (at least in part) to increased oil production, it has a far greater dependency on the commodity price. For example, although oil production continued to rise during 2001, its value and associated revenues for Colorado declined due to steeply declining oil prices (fig. 11).

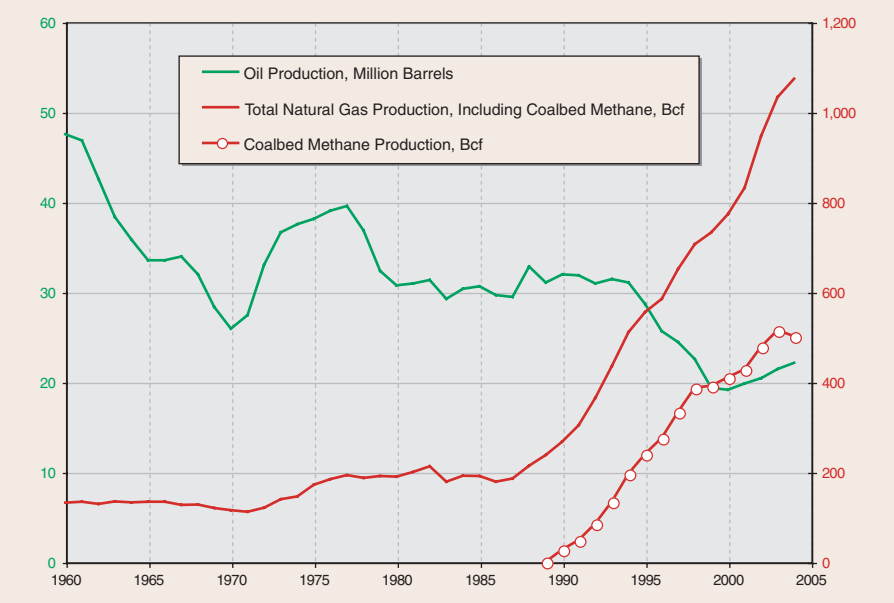

Figure 13: Colorado annual oil and natural gas production, including coalbed methane, 1960–2004 (COGCC).

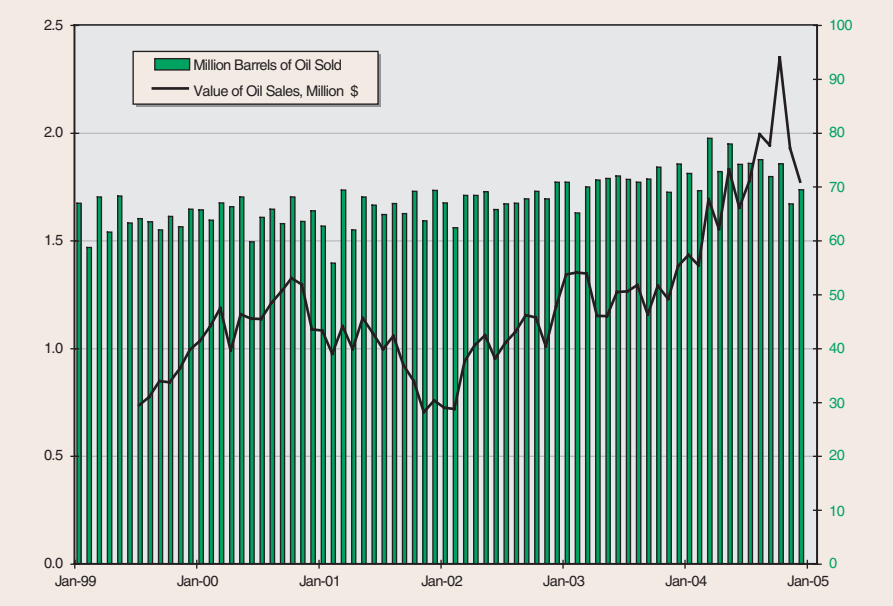

Figure 14: Colorado monthly oil production and value; monthly data from January 1999–December 2004, (COGCC).

Because of the tremendous boom in Rockies gas exploration and development, Colorado's average monthly gas production has been rapidly climbing by more than 10 percent per year since mid-1999 from 60 Bcf per month to about 90 Bcf per month by late 2004 (fig. 15). By contrast, the value of that production each month has gone from less than $150 million to more than $500 million per month during the same period, representing more than a three-fold increase in the value of the state's gas production. As with the value of oil production, the dramatic increase in the value of the state's gas production is a function of both increased production and highly volatile gas market prices (fig. 12).

County Rankings

Thirty-seven of Colorado's 64 counties produce either oil or natural gas, often both. For the purpose of ranking each county's contribution to the total value of the state's production, the sales volumes for each county have been assigned a value using the average annual composite oil and gas price indices ($38.78 per barrel oil and $5.54 per thousand cubic feet gas [Mcf], respectively). Based on the resulting production values computed for 2004, Colorado has three counties in which the annual production value exceeds $ 1 billion (La Plata, Weld, and Garfield) and five counties in which the annual production value is $100 million or more

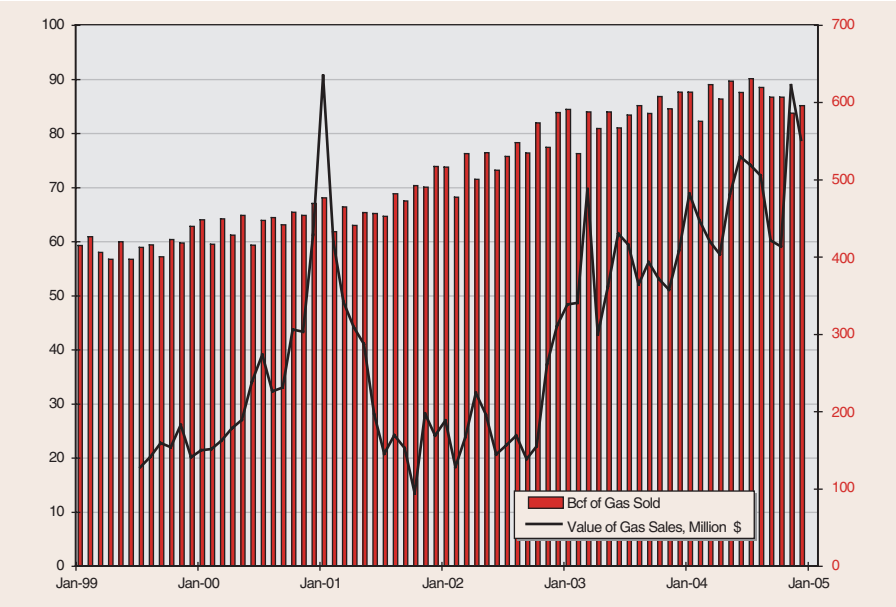

Figure 15: Colorado monthly gas production and value, January 1999–December 2004, (COGCC).

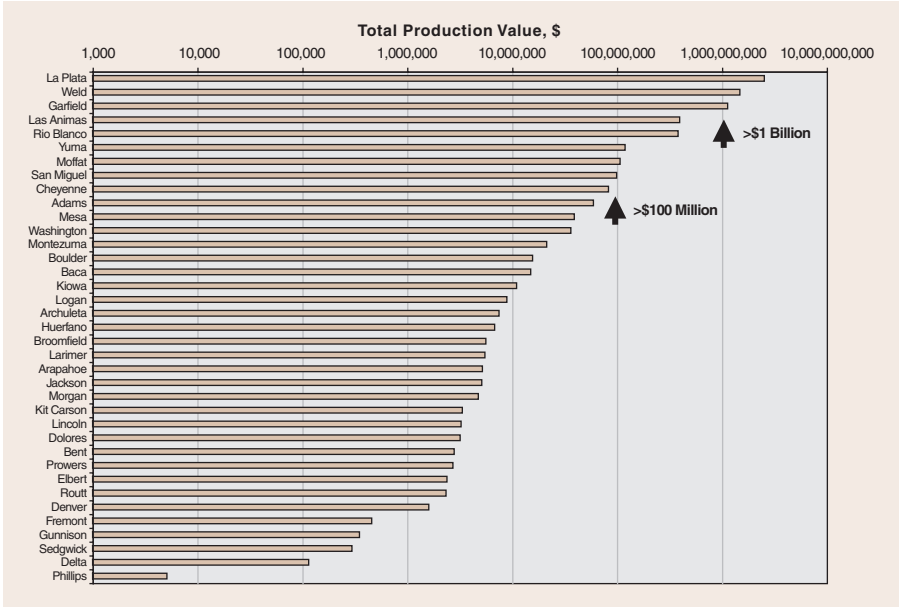

Figure 16: Oil and natural gas production value by county; annual data for 2004, (COGCC).

but less than $1 billion (Las Animas, Rio Blanco, Yuma, Moffat, and San Miguel) (fig. 16). The combined production value for these seven counties represents 95 percent of the total production value for the State of Colorado.

A significant portion of this value results from the production of natural gas. The same seven counties that top the rankings in total production value account for 97 percent of the total natural gas production sold for the state and nearly 80 percent of the total oil production sold. The top ranking counties in the sale of natural gas production for 2004 are La Plata, Garfield, and Weld, each with sales in excess of 100 Bcf for the year; Las Animas, Rio Blanco, Yuma, San Miguel, and Moffat counties each had sales of natural gas production in excess of 10 Bcf during the same period (fig. 17). The top ranking counties in oil production sold in 2004 are Weld, Rio Blanco, and Cheyenne with only Weld County reporting the sale of more than 10 million barrels of oil or nearly 50 percent of the oil sold in the state (fig. 18). The combined oil production sold for Weld and Rio Blanco counties represents nearly 75 percent of the total oil sales for the State of Colorado.

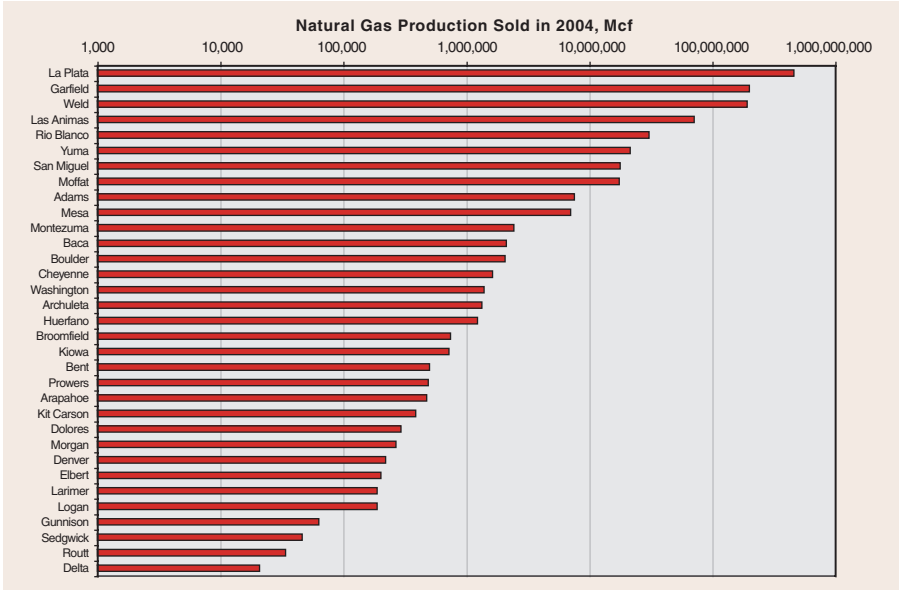

Figure 17: Total natural gas production sold for counties that sold more than 1,000 Mcf in 2004; annual data for 2004, (COGCC).

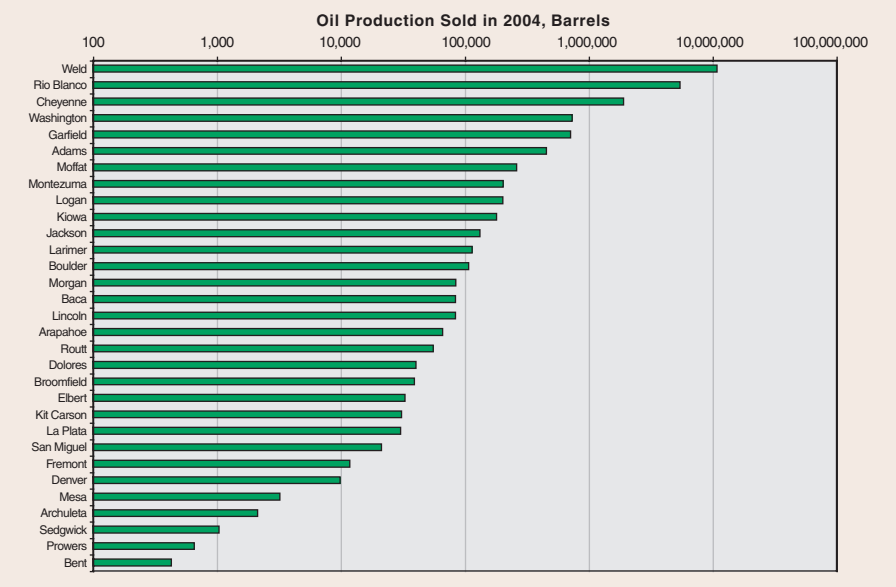

Figure 18: Total oil production sold for counties that sold any oil in 2004; annual data for 2004, (COGCC).

Oil and Gas Fields

The county rankings reflect the diversity in Colorado's oil and gas resource base. The Ignacio-Blanco field is located in La Plata County in the northern San Juan Basin and is a spectacularly-rich, gas producing province for the state (fig. 16). In excess of 90 percent of the gas sold in La Plata County is associated with the so-called "unconventional" coalbed methane resources of the Late Cretaceous Fruitland Formation. Oil and gas production also occurs from deeper horizons within the basin's Cretaceous sequence, including the Lewis Shale, Mesaverde Group, Mancos Shale, and Dakota Sandstone. Wattenberg is the 8th largest gas field in the U.S. in terms of proved reserves and the 7th largest in production. Wattenberg is also the largest oil field west of the Mississippi River, outside of Texas and California. It ranks 26th in oil reserves and 35th in oil production. Although the Wattenberg field straddles several counties within the Denver Basin, a significant portion of the field's production is located in Weld County (fig. 16). The western part of the basin, which is located along the eastern side of the Front Range, is rich in both oil and gas resources. The vast majority of production comes from the Cretaceous Dakota Group's Muddy J Sandstone and the Niobrara-Codell sequence. Production also occurs from the D Sandstone and the fractured Pierre Shale. The Wattenberg field's production averages about 23,000 barrels of oil and 0.5 Bcf of gas each day. This production is comprised of approximately 45 percent oil, 23 percent gas condensate, and 32 percent natural gas liquids (Wally O'Connell, Kerr-McGee, personal communication). Within the eastern portion of the Denver Basin, the relatively shallow Cretaceous Niobrara Chalk is now making a significant contribution through the production of biogenic gas—a play that is centered in Yuma County near the Kansas border.

Garfield and Rio Blanco counties have become synonymous with one of the "hottest" plays in the United States and in particular in the Rockies; that is, the Piceance Basin (fig. 16). The Piceance Basin hosts four fields with natural gas proved reserves in the nation's "Top 50" list of fields. Significant gas production occurs from the Paleocene–Late Cretaceous Fort Union Formation and the Late Cretaceous Mesaverde Group sandstones and coalbeds. In addition, significant oil production occurs from a thick interval spanning the Cretaceous to Pennsylvanian, including the Mancos Shale, Morrison Formation, Entrada Sandstone, the Shinarump Member of the Chinle Formation, and the Weber Sandstone.

The Rangely field, which is located in the northern Piceance Basin, produces from the prolific Permo-Pennsylvanian Weber Sandstone and accounts for Rio Blanco County's ranking of second in the sale of oil production for the state. Rangely is the largest oil field in the Rocky Mountains and is the 55th largest field in the U.S. in terms of proved reserves and 65th in terms of production.

Oil (and some associated gas) production in Cheyenne County occurs from Mississippian- and Pennsylvanian-age sandstone and limestone reservoirs along the Las Animas Arch. The Raton Basin located in western Las Animas County is the site of an aggressive coalbed methane play within the Late Cretaceous Raton and Vermejo Formations. The Raton Basin of Colorado and New Mexico ranks 9th in the nation in proved gas reserves. San Miguel County in the northern Paradox Basin reports the sale of more than 10 Bcf of gas produced from the Permo-Pennsylvanian Cutler and Hermosa Groups and the deeper Mississippian Leadville Limestone. Moffat County includes both the northernmost part of the Piceance Basin and the western two-thirds of the Sand Wash Basin. The county could be more easily described by what it does *not* produce from, as oil and gas sales are reported from numerous intervals from the Paleocene to deeper Pennsylvanian-age rocks. These include the Paleocene-Cretaceous Wasatch-Fort Union formations, Cretaceous Lance-Fox Hills-Lewis-Almond interval, Mesaverde Group sandstones, Mancos-Niobrara-Mowry shales, Dakota Group, Jurassic Morrison-Sundance-Entrada-Nugget sequence, Permo-Triassic Shinarump-Moenkopi-Phosphoria formations, Permo-Pennsylvanian Weber-Minturn formations.

Drilling Activity

COGCC reports that 3,284 applications for permit to drill (APDs) were received during 2004, representing a 34 percent increase over the 2,448 APDs received in 2003. Of those received in 2004, there were 99 withdrawn and the remaining 3,062 applications were approved. The vast majority of the applications received

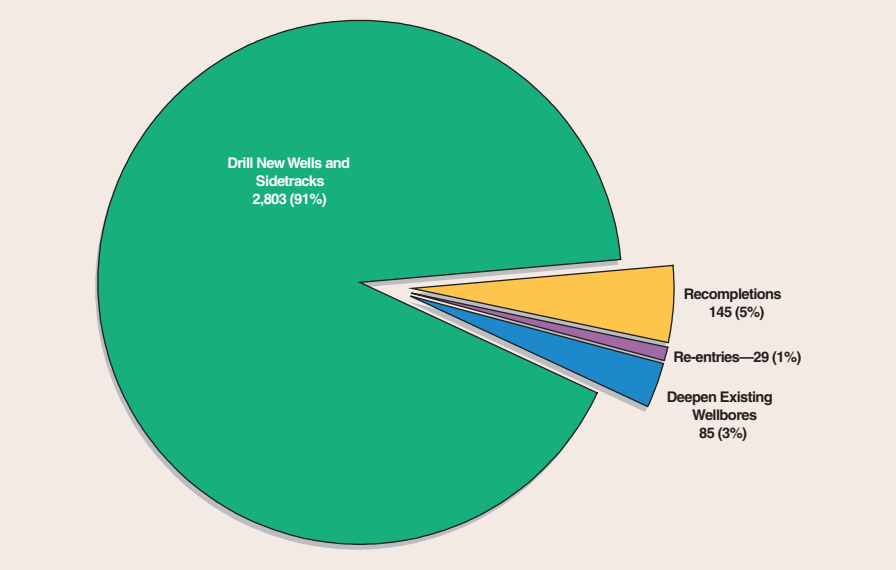

Figure 19: Types of applications for permit to drill (APDs) approved during 2004, (COGCC).

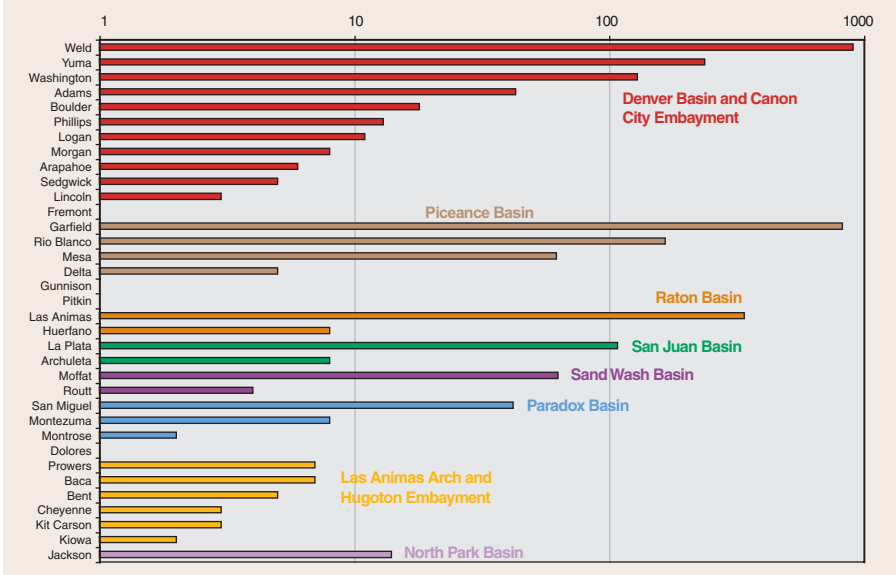

Figure 20: Applications for permit to drill approved for each county in 2004, (COGCC).

during 2004 were for drilling new wells or sidetracking existing wellbores; that is, 91 percent or 2,803 permits were approved for drilling new wells (fig. 19). The remaining 259 permits consisted of requests for deepening, recompleting, or re-entering existing wellbores.

The three counties for which the most drilling permits were approved in 2004 are Weld, Garfield, and Las Animas (fig. 20) and reflect the strong focus of exploration and development efforts in the Denver, Piceance, and Raton basins, respectively. Of the total 3,062 applications that were approved in 2004, about 91 percent or 2,785 were for drilling activity in the Denver, Piceance and Raton basins (fig. 21). In addition to the proposed drilling activity in Colorado's more mature areas such as the San Juan and Paradox basins, applications were also approved in 2004 for emerging resource areas such as the coalbed methane potential in the Sand Wash and North Park basins.

The annual average monthly rotary drill rig count for Colorado was 54 during 2004—up more than 38 percent from the average of 39 for 2003 (Baker Hughes, 2004). This average represents about 4.5 percent of the total 1,190 rigs operating monthly in the U.S. during 2004.

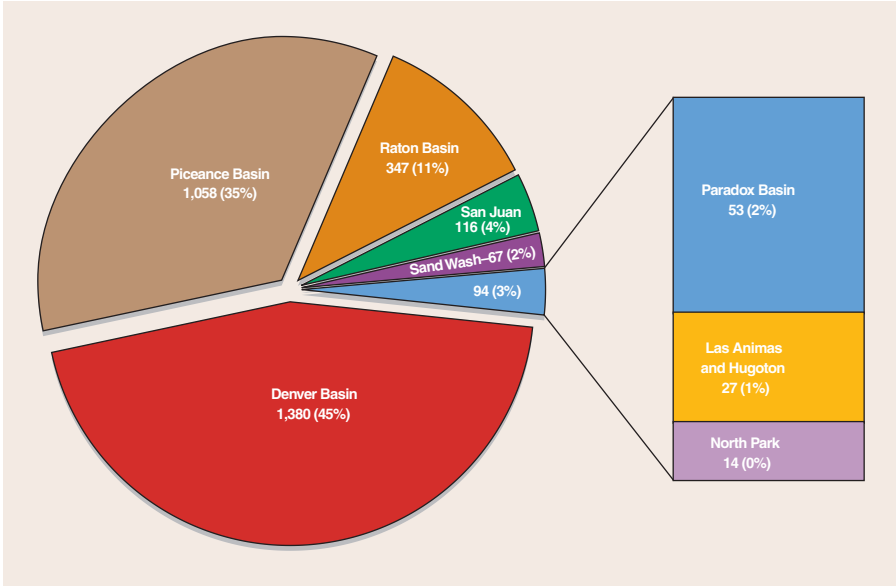

Figure 21: Basin distribution in approved applications for permit to drill in 2004, (COGCC).

Reserves

The Energy Information Administration (EIA) defines proved reserves as those volumes of oil and gas that geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Proved reserves are either proved producing or proved non-producing; that is, resident in reservoirs that did not produce during the report year. Non-producing may represent a substantial fraction of total proved reserves.

Crude Oil

EIA (2004) reports that Colorado had 217 million barrels of crude oil proved reserves as of December 31, 2003, which represents an increase of 1.4 percent or 3 million barrels from the end of 2002 (fig. 22). Nationally, crude oil proved reserves declined 3 percent during the same period, from 22.7 billion barrels at the end of 2002 to 21.9 billion barrels at the end of 2003.

The slight increase in Colorado's crude oil proved reserves resulted from reserve revisions, sales and acquisitions, and extensions of existing oil fields; no new field discoveries or new reservoir discoveries in old fields were reported for 2003 (EIA, 2004). Revisions to proved reserves occur each year as infill wells are drilled, well performance is analyzed, new technology is applied, or economic conditions change.

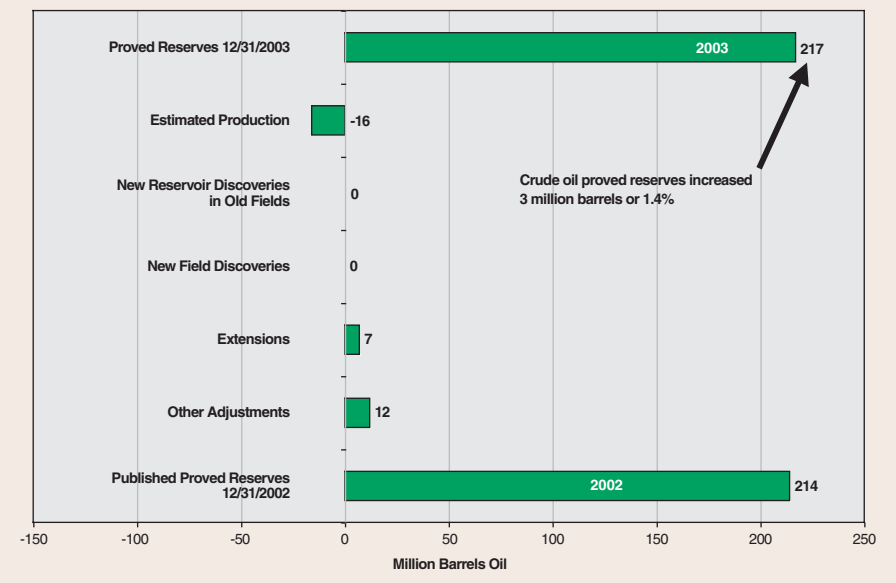

Figure 22: Colorado crude oil proved reserves, reserves changes, and production for 2003, (EIA, 2004).

Not all proved reserves of crude oil reported in 2003 were producing. Colorado reported 61 million barrels of proved reserves in non-producing status—nine percent more than the 56 million barrels reported in 2002 (EIA, 2004; EIA, 2003). Non-producing reserves are those awaiting well workovers, the drilling of extensions or additional development wells, installation of production or pipeline facilities, and depletion of other zones or reservoirs before recompletions in reservoirs not currently open to production.

There are more than 45,000 oil and gas fields in the U.S. with the top 100 fields containing two-thirds of U.S. crude oil proved reserves. EIA (2004) ranked the top 100 oil and gas fields based on reserves and 2003 field level production data. In terms of the nation's largest oil fields, Colorado has two fields in the top 100—Wattenberg and Rangely. The Wattenberg field, discovered in 1970 in the Denver Basin, ranked as the 26th largest oil field in the nation based on liquids proved reserves (liquids includes both crude oil and lease condensate) and 35th based on liquids production of 8.6 million barrels in 2003. The Rangely field, discovered in 1902 in the Piceance Basin, ranked as the 55th largest oil field based on liquids proved reserves and 65th based on liquids production of 4.7 million barrels in 2003.

Natural Gas

EIA defines "dry" natural gas as the actual or calculated volumes of natural gas that remain after: (1) the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field, and/or plant separation), and (2) any volumes of non-hydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable.

Nationally, dry natural gas reserves additions were 11 percent more than production in 2003. Gas production itself increased 0.4 percent in 2003 (EIA, 2004). Six areas account for 73 percent of the nation's dry natural gas proved reserves; among this list is Colorado with 8 percent of total U.S. gas reserves (table 2). Colorado, Texas, Wyoming, and Oklahoma dominated dry gas reserves additions in 2003. This activity continues the trend of developing so-called "unconventional" gas fields—that is, tight sands, shales, and coalbeds. At the end of 2003, Colorado had 15.4 Tcf of proved dry natural gas reserves (table 2). Colorado's reserves increased more than 11 percent or 1.55 Tcf from the end of 2002—*the single largest gain of any other state during 2003* (fig. 23).

The largest component of total discoveries in 2003 was extensions of existing gas fields. Nationally, field extensions were 16.5 Tcf, 11 percent more than 2002 and 66 percent more than the prior 10-year average of 10 Tcf. Colorado was the sixth largest extension-reporting areas with 1.2 Tcf or seven percent of the total U.S. reserve extensions for 2003 (fig. 23). The estimated 2003 U.S. dry natural gas production was nearly 20 Tcf. Colorado's annual gas production of over one Tcf represented six percent of total U.S. production.

Table 2: Colorado ranks 5th in gas reserves in the U.S., 2003, source EIA data.

Area	Percent of U.S. Gas Reserves	Proved Gas Reserves, Tcf (12/31/2003)
Texas	24	45.7
Wyoming	12	21.7
Gulf of Mexico Federal Offshore	12	21.1
New Mexico	9	17.0
Colorado	8	15.4
Oklahoma	8	15.4
Area Total	**73**	**136.3**

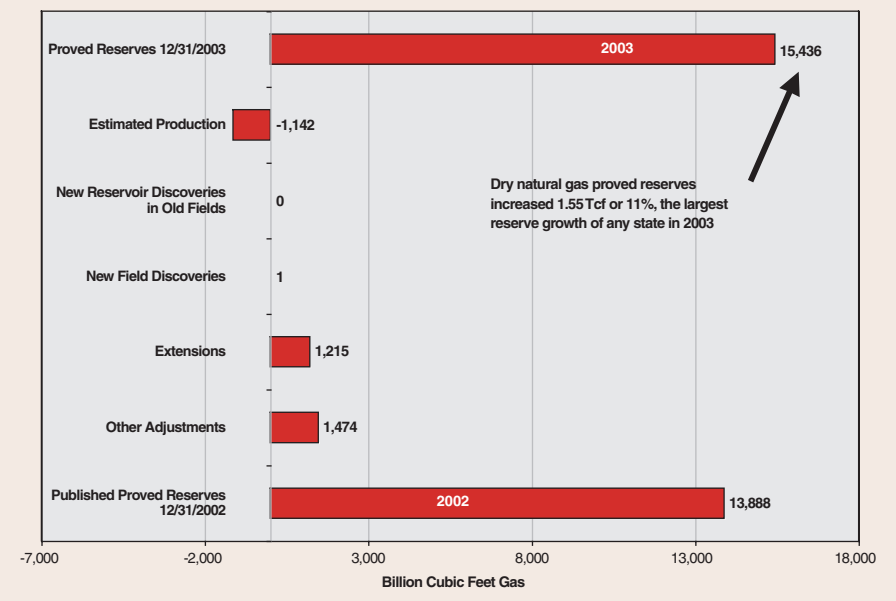

Figure 23: Changes in Colorado dry natural gas proved reserves and production for 2003 (EIA, 2004).

In terms of the nation's largest gas fields, Colorado has all, or parts of, seven gas fields in the top 50 based on proved reserves—San Juan Basin, the Wattenberg field in the Denver Basin, Raton Basin, and the Mamm Creek, Rulison, Grand Valley, and Parachute fields in the Piceance Basin (EIA, 2004; table 3). Of these gas-rich areas, the San Juan Basin, Wattenberg field, and Raton Basin rank in the top 10 in the U.S. Most notably, the Ignacio Blanco/Blanco gas fields of the San Juan Basin Gas Area in Colorado and New Mexico represent the largest gas proved reserves for the entire nation and also had the highest gas production of 1.5 Tcf estimated for 2003.

Table 3: Colorado gas fields ranked in top 100 U.S. gas fields. Proved reserves and production from estimated 2003 field level data, EIA data.

Field Name	Location	Discovery	Reserves Rank	Production Rank	Production Volume, Bcf
San Juan Basin	Colo.& N. Mexico	1927	1	1	1,479.6
Wattenberg	Colorado	1970	8	7	194.2
Raton Basin	Colo.& N. Mexico	1998	9	16	94.7
Mamm Creek	Colorado	1959	18	36	57.5
Rulison	Colorado	1958	23	> 100	30.1
Grand Valley	Colorado	1985	27	96	31.2
Parachute	Colorado	1985	44	> 100	24.0

Coalbed Methane

Nationally, proved reserves of coalbed methane increased to 18.7 Tcf in 2003—a one percent increase over the 2002 level of 18.5 Tcf (EIA, 2004). Coalbed methane accounted for 10 percent of all 2003 dry natural gas reserves in the U.S. Five states (Colorado, New Mexico, Wyoming, Utah, and Alabama) currently have 88 percent of the U.S. coalbed methane proved reserves. With nearly 35 percent (65 Tcf) of the total U.S. reserves, Colorado ranks first in the nation for coalbed methane proved reserves, even though the state's reserves declined three percent during 2003. During this same period, however, Colorado coalbed methane production increased 7.5 percent to 514 Bcf in 2003 (COGCC, 2003). In 2003, reserves declined by less than production; thus, reserves were gained by development drilling.

Colorado coalbed methane production in 2004 decreased 2.6 percent to 501 Bcf (COGCC, 2004). The state's coalbed methane production, however, continues to be the highest in the nation for the third consecutive year.

Trends, Developments and Forecasts

As our nation relies more heavily on natural gas, exploration and development efforts are increasingly focused on the gas-rich Rocky Mountains. Proved reserves of natural gas increased for the fifth consecutive year in the U.S. The majority of natural gas discoveries were from extensions of existing conventional and unconventional gas fields. Colorado's net increase of 1.548 Tcf of dry natural gas proved reserves in 2003 represented the largest of any of state in the nation. Increases in gas production from Colorado and other Rocky Mountain States as well as Texas have offset the declines in production from areas such as the Gulf of Mexico and New Mexico, allowing U.S. gas production to remain fairly level for the last couple of years. The tight sands and coalbed methane resources of the Denver, Piceance, Raton, and San Juan basins are of strategic importance to the nation's energy supply.

Volume, Value, and Prices

Production volumes for 2005 and 2006 are expected to increase an average of 12 percent over the next two years due to aggressive drilling programs throughout the state. Based upon price increases in 2003 and 2004, the value of that production is forecast to be at least 20 percent higher through 2005. Production value for crude oil and natural gas is forecast to be about $7.5 billion for 2005 and may approach $9 billion for 2006.

Oil prices for the next year or two are forecast to be in the $40 to over $50 per barrel range as a result of continued unrest in the Middle East and potential instability in other OPEC nations (such as Venezuela and Nigeria) and Russia, as well as increased demand from emerging economies such as China. (OPEC is the Organization of Petroleum Exporting Countries.) These prices might be reduced to the $30 to $35 per barrel range if (1) interest rates continue to increase, which reduces the attractiveness of commodities as an investment vehicle, and/or (2) stability returns to the Middle East.

Natural gas prices will probably continue in the range of $4 to over $6 per Mcf through the end of 2005. However, natural gas prices are expected to be even more volatile than oil because of deliverability obstacles, increasing demand from electric generation, and uncertainties in the weather and oil markets. Deliverability obstacles include a distribution system already filled to capacity in many areas and a need for more storage and distribution of liquefied natural gas.

Mergers and Acquisitions

The trend in the mergers and acquisitions market during 2004 has resulted in several local firms selling their portfolios to larger, financially stronger firms—Evergreen Resources sold to Pioneer Natural Resources, Westport Resources sold to Kerr McGee Corporation, and Tom Brown sold to EnCana. These transactions exceeded $8 billion in asset transfers and represented a natural gas reserve value of nearly $2 per Mcf. Opportunities such as these offer an immediate and less expensive way for buyers to enter the Rockies. Finding and development costs for natural gas in the Rockies are about $0.50 per Mcf more than the current acquisition price for such reserves. This differential is due partially to the costs and uncertainties associated with land access, permitting, and geologic risks.

In the 2004 mergers and acquisition market, about 50 percent of the purchase price was paid for proved, developed, and producing reserves. The remainder of the purchase price was based on reserves in the potential and possible categories; that is, reserves that have not even been booked at the time of purchase. Buyers such as Pioneer, Kerr McGee, and EnCana are attracted by strong lease positions with data already developed by the selling firms (Evergreen, Westport, Tom Brown), which provides a significant time advantage over raw exploration. This trend in asset transactions is expected to continue for Colorado and the Rocky Mountains through 2005.

Pipelines

The Kern River pipeline expansion, which serves southern California markets, is 100 percent subscribed and is now operating at full capacity. This expansion added 0.9 Bcf per day when it was completed in May 2003, yielding a total pipeline capacity of 1.7 Bcf per day in gas transportation from Colorado and the Rockies to markets in southern California.

Cheyenne Plains Gas Pipeline Company has completed a new 36-inch, 380-mile natural gas pipeline project, extending from near the Wyoming-Colorado border to south-central Kansas. The Cheyenne Plains Pipeline will serve markets in the Midwest with connections to several mid-continent pipelines near Greensburg, Kansas. The Cheyenne Plains pipeline went into operation January 2005 with a capacity of 0.560 Bcf per day, which is currently 25 percent subscribed (Brendan Muller with Mercator, personal communication). An expansion to 0.73 Bcf per day is projected by the end of 2005.

EnCana's affiliate, Entrega Gas Pipeline, is constructing a 330-mile natural gas pipeline beginning at the Meeker Hub in Rio Blanco County and terminating at the Cheyenne Hub in Weld County. The Entrega pipeline will follow existing pipeline corridors and should be completed in either the fourth quarter 2005 or first quarter 2006. The pipeline will have a capacity 1.3 Bcf per day.

It is not known how these two new pipelines will impact local gas prices in Colorado. However, industry analysts expect that the Henry Hub differential will remain in the -$0.80 to -$0.85 per million Btu range through 2006.

Notable Reserve Additions

Colorado had a net increase of 1.548 Tcf of dry natural gas proved reserves in 2003, the largest of any State. This was primarily because of development of the Wattenberg field, the Mamm Creek field, and coalbed methane reserves in the Raton Basin.

Wattenberg Field: Kerr-McGee Corporation's natural gas exploration and field exploitation programs help meet strong domestic demand. Use of 3-D seismic surveys, new well-stimulation techniques and creative collaboration with service companies enable the company to extract additional production from mature fields. About one-third of Kerr-McGee's worldwide 2003 natural gas production flowed from tight sands in Colorado and South Texas. These unconventional reservoirs consist of less permeable rock than conventional fields but are long-lived and generate predictable cash flow at low unit cost. Kerr-McGee operates more than 3,100 wells and a 1,600-mile gathering system in the Wattenberg field. Production techniques include infill drilling, fracture stimulation, deepening of existing wells and recompletions (fig. 24).

Mamm Creek Field: EnCana Corporation has achieved tremendous growth over the past couple of years from Mamm Creek field in the Piceance Basin. This is a

success story of continuous innovation. Mamm Creek's gas-bearing zone (fig. 25) is typically 2,500 feet thick. These tight sandstone reservoirs contain large volumes of natural gas trapped in low-permeability rock, which requires the application of high-pressure fracturing techniques (fig. 26). Previously, the accepted technique called for splitting the gas-bearing interval into just a few zones for fracture stimulation, yielding typical initial gas production rates of about 500 Mcf per day. Through experiment and pilot testing, EnCana has increased these rates by increasing the frequency of stimulation over narrower intervals. Instead of two large fracture stimulations, EnCana now routinely performs up to eight stimulations across the same 2,500-foot interval. With this improved approach, production can be tripled to more than 1.4 million cubic feet per day from the same tight gas zone.

Figure 24: Drill rig in Weld County; photograph courtesy Brian Macke, COGCC.

Figure 25: The Upper Cretaceous Williams Fork Formation is a very thick, highly-productive sedimentary interval in the subsurface of the Piceance Basin; photograph of a prominent sandstone bed in Coal Canyon, Mesa County.

Figure 26: EnCana using multiple drill rigs on a single pad to drill and fracture stimulate wells in Garfield County; photograph courtesy Brian Macke, COGCC.

Carbon Dioxide

Carbon dioxide (CO_2) floods are enhanced oil recovery (EOR) projects that have consistently and significantly increased annual EOR production since the 1986 crash in oil prices. According to the 1998 *Oil & Gas Journal* CO_2 survey, more than one-half of the U.S. EOR gas production and one-fifth of all U.S. EOR oil production came from CO_2 flood projects (Moritis, 1998).

Projects in the U.S. comprise about 95 percent of the current worldwide CO_2 EOR production. Based on EOR incremental rates, the Rangely Weber Sand miscible CO_2 flood in the northern Piceance Basin is the third largest EOR producing project worldwide and in the U.S. The Rangely project produces about 14,000 EOR barrels of oil per day.

The most active CO_2 flooding area in the U.S. is the Permian Basin located in west Texas and eastern New Mexico. Here, 50 projects produce an incremental 145 million barrels of oil per day—more than 80 percent of the current North American enhanced oil produced from CO_2 floods. An extensive CO_2 pipeline and re-injection infrastructure system exists throughout the Permian Basin, making it attractive for expanding or starting new projects. High-pressure pipelines supply CO_2 from natural source fields at Bravo Dome in northern New Mexico, and McElmo Dome and Sheep Mountain in southern Colorado. Shell's completion of the pipeline out of McElmo Dome in 1983 significantly increased the value of the naturally occurring CO_2 reserves in Colorado. In addition to EOR applications, CO_2 is used in welding, the manufacture of dry ice, and the food and beverage industry.

The largest natural CO_2 reserves are located at LaBarge-Big Piney Field in Wyoming (~20 Tcf), Bravo Dome in New Mexico (~12 Tcf), and McElmo Dome in Colorado (~12 Tcf). Sheep Mountain in the northern Raton Basin in southeastern Colorado has an estimated 2 Tcf in ultimate CO_2 recovery. The CO_2 from McElmo and Sheep Mountain is very high quality—that is, 95 and 97 percent CO_2, respectively.

The total value of carbon dioxide production in Colorado was nearly $130 million in 2004—an increase of 31.6 percent over the value $98 million in 2003. Montezuma County produced 320 Bcf or 94 percent of Colorado's total carbon dioxide in 2004 (fig. 27). The Mississippian Leadville Limestone at the McElmo Dome field supplies carbon dioxide for EOR applications in the Permian Basin. Dike Mountain and Sheep Mountain fields in the northwestern part of the Raton Basin in Huerfano County produced six percent of the state's total carbon dioxide in 2004. McCallum and McCallum South fields in the northeast part of the North Park Basin in Jackson County contributed less than one percent of the state's total carbon dioxide production in 2004.

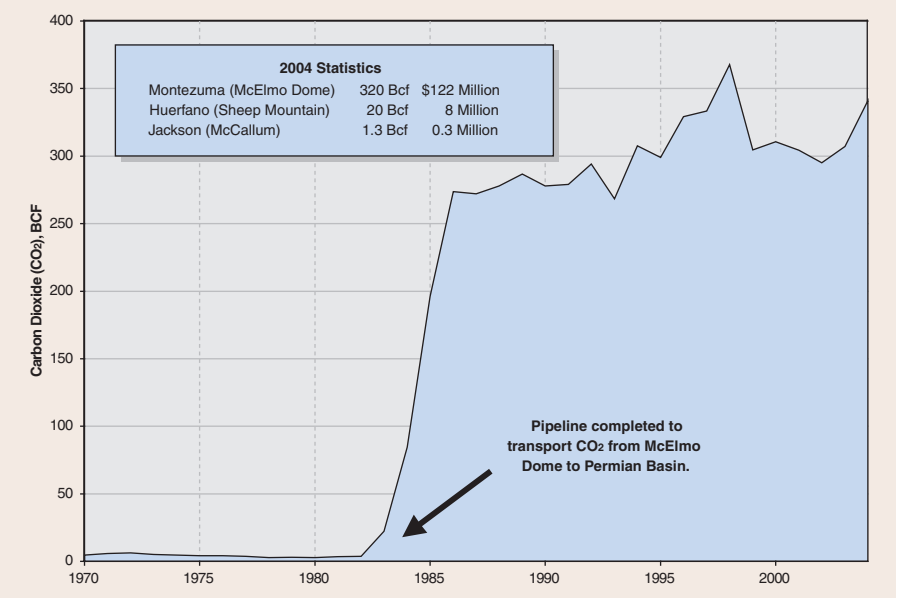

Figure 27: Carbon dioxide production; annual data for 1970–2004, (COGCC).

COAL

Introduction

The coal industry in Colorado had its best year ever in 2004. For the seventh time in eight years, the 12 producing Colorado coal mines broke the state's annual coal production record. Last year, nearly 40 million tons of coal were produced, smashing the previous mark set in 2003 by over 11 percent (fig. 28). This high production record also brought increased employment (over 1,900 miners employed), and higher spot prices for coal sales that neared the $30 per ton mark.

All of the producing mines operated without major delays or hazards. The only sectors of the industry with difficulties are the railroads, which need to supply more trains to meet the ever-increasing coal production. In terms of economic productivity, the 12 coal mines in the state all operated at or near capacity. Colorado's compliant coal product was much in demand, keeping our low ash, high Btu, low sulfur product in the national marketplace.

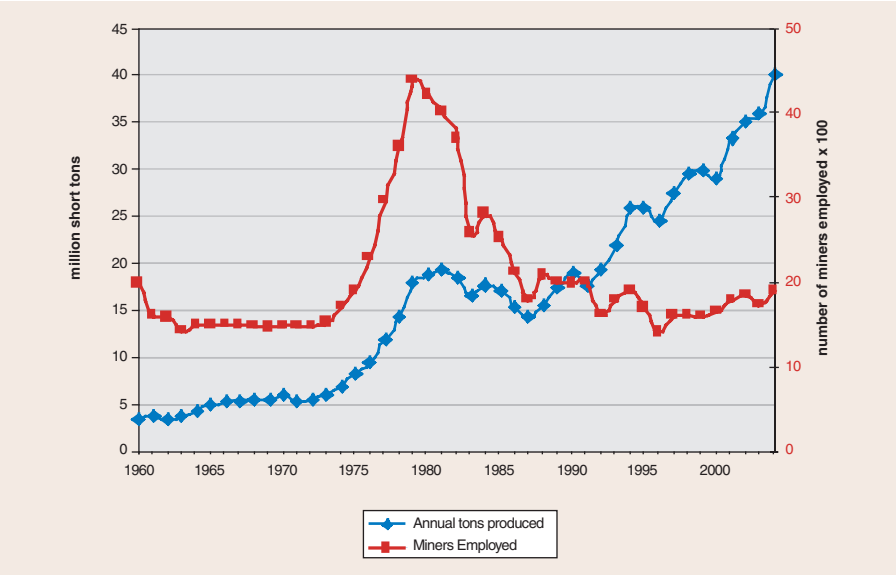

Figure 28. Coal production and employment of miners in Colorado, 1960–2004.

Colorado coal in the national marketplace

Table 4 shows the nation's ten largest coal-producing states as of March 2005. Colorado ranks sixth in coal production nationally. Western states increased coal production in 2005. Montana and Texas show large increases while Colorado shows a 3.2 percent increase, the same as the national average. Many of the eastern coal producing states show decreasing production over 2004.

Table 4: Ten largest coal producing states as of March 19, 2005. Production is in thousands of tons; YTD = year to date. Source: U.S. Department of Energy's Energy Information Administration (EIA) weekly data.

Ranking	State	YTD 2005	YTD 2004	% Change from 2004
1	Wyoming	85,571	83,615	2.3
2	West Virginia	32,728	31,927	2.5
3	Kentucky	24,055	25,099	-4.2
4	Pennsylvania	12,730	14,917	-14.7
5	Texas	10,680	9,323	14.6
6	Colorado	9,084	8,802	3.2
7	Montana	8,802	7,789	13.0
8	Indiana	7,427	7,766	-4.4
9	Illinois	6,724	7,599	-11.5
10	Virginia	6,461	7,165	-9.8

Since 1999, states west of the Mississippi River have produced more coal than the traditional eastern coal-producing states (both Appalachian and Interior Regions) (fig. 29).

Factors relating to increased demand for Colorado coal include: 1) requests for compliance coal as eastern supplies diminish; 2) a shortage of cheap fuel as the spot price for eastern coal increases; and 3) a colder than normal winter in the northeast. A national supply shortage of compliance coal brings Colorado's supply into high demand. U.S. electric power generation increased by 1.8 percent in 2004 from the previous year. Generation from coal-fired plants dropped slightly to 50 percent of the nation's power supply, while natural gas increased to 17.7 percent and hydroelectric increased to 6.6 percent. Nuclear energy, although absent from Colorado electricity generation for some time now, increased slightly to 19.9 percent nationally.

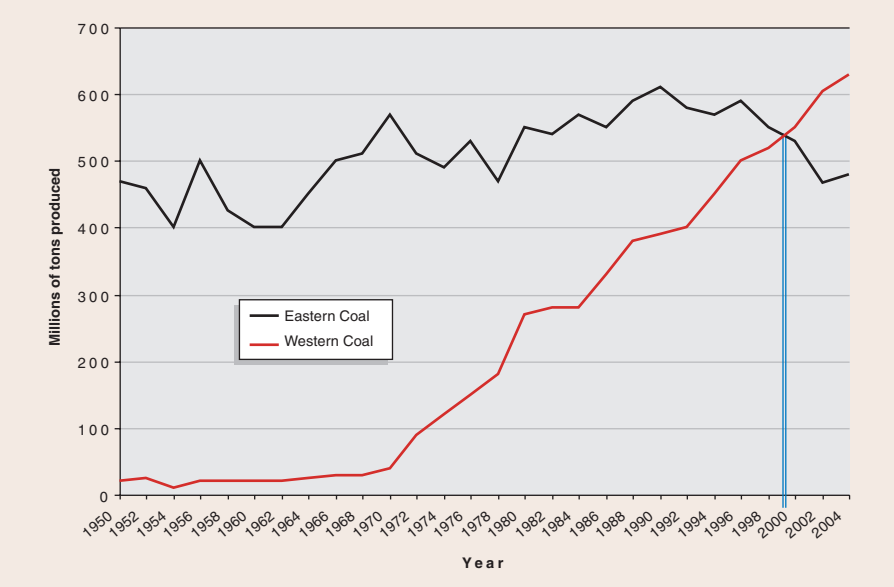

Figure 29:. Chart comparing western and eastern coal production trends, 1950–2004. Source: Mine Safety and Health Administration data.

Coal prices and growth of the industry

In 2004, the spot market price for U.S. coal ramped up considerably. According to EIA, the spot price of Uinta Basin bituminous coal increased from $17 per ton to $29 per ton (fig. 30). Spot prices for central Appalachian coal increased from $35 per ton to over $60 per ton. This increase in price for eastern coal now provides a margin that helps western coal marketers.

Nationally, the spot sales price for low-sulfur bituminous Uinta Basin coal is $29 per ton; however most of the Colorado coal sells at lower contract prices. The Colorado Department of Local Affairs tracks the sales of coal in Colorado from Federal leases, which are about 75 percent of the active coal producing areas. The average price per ton from these leases for 2004 was $18.09. However, some undetermined amount of Colorado coal is sold on the spot market for values of up to $29 per ton. The Colorado Geological Survey estimates an average value of $20 per ton to account for contract and some spot sales, resulting in a coal production value of $800 million for 2004.

For the first three months of 2005, these healthy economic trends appear to be continuing, as the spot price of coal, employment, and coal production are all sustained at high values. Also note that there are thirteen coal mines operating at 12 coal mine operations in Colorado: the Yoast and Seneca II-W mines are combined as one unit (fig. 31).

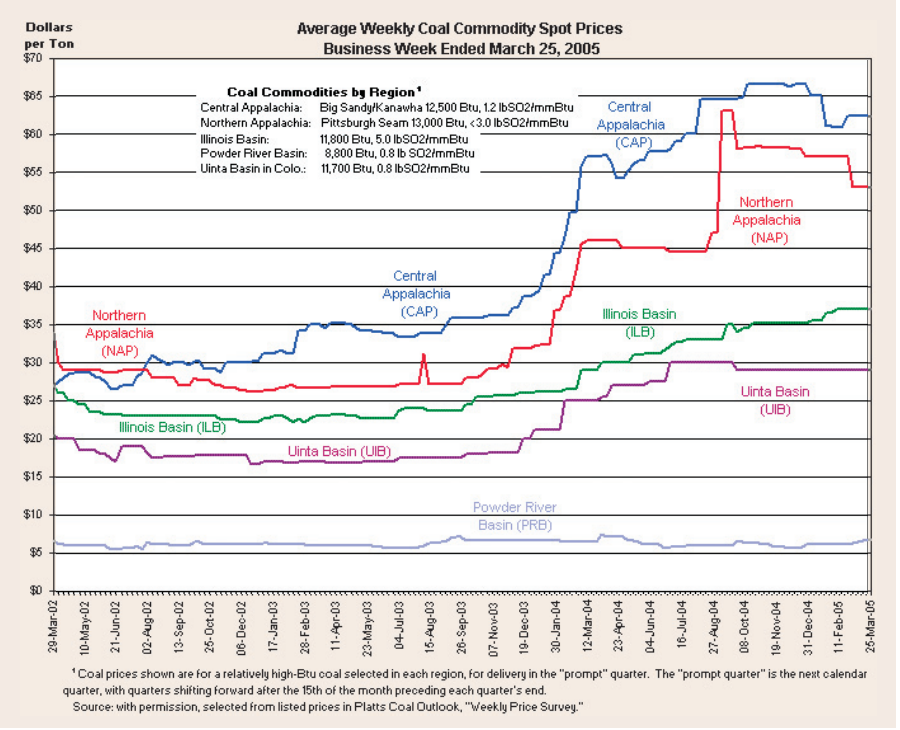

Figure 30. Spot sales price for domestic coal by region and type. Source: EIA 2005.

The rising prices in oil and natural gas in the past year sparked a similar spike in the price of coal. The demand for coal is exceeding the supply because it is still relatively cheap and very reliable.

At the February 2005 National Western Mining Conference in Denver several speakers discussed the state of the Colorado coal industry. Charles Burggraf, Peabody Energy chief of Colorado operations, stated that world growth of the coal industry will depend on increased consumption in the U.S., China, Japan, and India. Coal consumption in these countries is expected to grow between 251 million and 1.37 billion tons annually by 2025. By 2006, China plans to have 63,000 megawatts more power online, representing about 200 million tons of coal consumption per year.

Bret Clayton of Kennecott Corp. discussed the importance of western coal and its growth in production since 1980. Over 50 gigawatts of coal-fired electric generation have been proposed nationally and most will burn western coal. He also remarked on the environmental aspects of coal-fired power plants. The total amount of NO_x, SO_2 and particulate emissions have dropped since 1970, while total net electricity generation has increased by 77 percent in the same time.

2004 Colorado coal supply

A combination of high demand, favorable mining conditions, larger mining equipment, and high prices enabled record-breaking coal production in 2004. Of the 40 million tons produced, nearly 30 million tons came from eight underground mines, while 10 million tons came from five surface mines (see fig. 31 for mine locations; table 5 for mine statistics). Most of the coal mined in Colorado is bituminous (approximately 79 percent of the state's production); only two mines produced sub-bituminous products (Trapper and Colowyo mines). Twentymile Coal's Foidel Creek Mine and Mountain Coal's West Elk Mine ranked in the top ten largest underground mines in the nation. Kennecott's Colowyo Mine, the largest surface mine in Colorado, is the nation's 25th largest surface mine.

Coal was produced in eight Colorado counties last year. For the third year in a row the state's top coal producer was Gunnison County (table 6), with over 13 million tons. Mountain Coal Company's West Elk Mine and Oxbow Mining Co.'s Elk Creek Mine, both with large underground longwall miners, produced over 6.5 million tons each. Statewide, the three highest coal-producing counties were, in order, Gunnison, Routt, and Moffat counties, which accounted for over 78 percent of the state's coal production. Gunnison County coal mines also claimed the most miners employed (589) as of December 2004.

Table 5. Colorado coal mine statistics, 2004. Source: Colo Div. of Minerals and Geology 2004 production data. See Figure 31 for mine locations.

Mine No.	County	Parent Company	Operator	Mine Names	Coal Region	Coal Field	Twp., Rng.	Geologic Formation	Producing Bed Names	Seam Thickness (ft)	BTU Avg.	Mine Type	Mining Method	2004 Prod. (tons)	Dec 2004 Miners	Shipment Method
1	Delta	Colorado Energy Investments, LLC; Sentient Coal Resources, LLC	Bowie Resources Ltd.	Bowie #2	Uinta	Somerset	13S, 91W	Mesaverde	D	7–12	12,053	U	Longwall, continuous	4,108,077	100	Truck, rail
2	Delta	Colorado Energy Investments, LLC; Sentient Coal Resources, LLC	Bowie Resources Ltd.	Bowie #3	Uinta	Somerset	13S, 91W	Mesaverde	B	12–20 ft	11,650	U	Longwall, continuous	**587,990**	114	Rail
3	Gunnison	Oxbow Carbon and Minerals Holdings, Inc.	Oxbow Mining, LLC	Elk Creek	Uinta	Somerset	13S, 90W	Mesaverde	D2	D=6–19 ft. D2 seam minable is 14 ft.	12,375	U	Longwall, continuous	**6,549,034**	272	Rail
4	Gunnison	Arch Coal Inc.	Mountain Coal Company, Inc.	West Elk	Uinta	Somerset	13S, 90W	Mesaverde	B,E	B 12, E 12	11,650	U	Longwall, continuous	6,591,183	317	Rail
5	La Plata	Alpha Natural Resources	National King Coal, LLC	King Coal	San Juan River	Durango	35N, 11W	Upper Menefee	Upper Bed	52–72 in.	12,800	U	Continuous	**460,609**	54	Truck
6	Garfield	Central Appalachian Mining (CAM)	CAM	McClane Canyon	Uinta	Book Cliffs	7S, 102W	Mesaverde	Upper Cameo, Lower Cameo	Upper Cameo: 5–9 ft; Lower Cameo: 8–10 ft	10,475	U	Continuous	289,495	22	Truck
7	Moffat	Kennecott Energy Co.	Colowyo Coal Company, L.P.	Colowyo	Uinta	Danforth Hills	4N, 93W	Williams Fork–Fairfield Coal Group	A-F,X,Y	52.2 ft total; Y=4 ft, X=10.7 ft, A=2 ft, B=6.8 ft, C=6.4 ft, D=10.1 ft, E=6.8 ft, F=5.4 ft	10,453	S	Dragline, Shovels, Dozers	**6,379,546**	247	Rail
8	Moffat	PacifiCorp/Tri-State G&T/Salt River	Trapper Mining, Inc.	Trapper	Green River	Yampa	6N, 90W	Williams Fork–Upper Coal Group	H, I, K, L, M, Q	H=6 ft, I=5 ft, K=4 ft, L=4 ft, M=6 ft, Q=10 ft	9,850	S	Dragline, Shovels, Hyd. Excav.	1,837,102	133	Truck
9	Montrose	Tri-State G&T Assoc.	Western Fuels Colorado, LLC	New Horizon	San Juan River	Nucla-Naturita	46N, 15W	Dakota	1, 2	1: 0.80–1.5 ft; 2: 5.0–7.5 ft	11,680	S	Shovels, dozers	**413,332**	21	Truck
10	Rio Blanco	Deseret Generation & Transmission	Blue Mountain Energy, Inc.	Deserado	Uinta	Lower White River	3N, 101W	Williams Fork	B Seam	B: 7–16 ft., D: 6–8 ft.	10,000	U	Longwall, continuous	**2,552,762**	151	Rail
11	Routt	RAG American (now Peabody Energy 3/04)	Twentymile Coal Co.	Twentymile (Foidel Creek)	Green River	Yampa	5N, 86W	Williams Fork–Middle Coal Group	Wadge	8.5–9.5 ft	11,250	U	Longwall, continuous	**8,557,745**	360	Rail
12	Routt	Peabody Energy	Seneca Coal Co.	Seneca II-W	Green River	Yampa	5N,87W	Williams Fork–Middle Coal Group	Wadge, Wolf Cr., Sage Cr.	Wadge: 8.9–12.2 ft (avg. 11.7 ft); Wolf Creek: avg. 20.4 ft; Sage Creek: 3.4–5.4 ft (avg. 4.6 ft)	11,908–12,581	S	Dragline, loaders	673,124	57	Truck, rail
13	Routt	Peabody Energy	Seneca Coal Co.	Yoast	Green River	Yampa	5N,87W	Williams Fork–Middle Coal Group	Wadge, Wolf Cr.	Wadge: 0.39–14.2 ft (avg. 12.2 ft); Wolf Creek: 15.8–16.7 ft (avg. 16.0 ft)	11,908–12,581	S	Dragline, loaders	815,925	57	Truck, rail
Total				**Shaded part indicates new annual production record.**										**39,815,924**	**1,905**	
				Mine Type abbreviations: U—underground mine, S—surface mine						Shaded section of production is a record for that mine.						

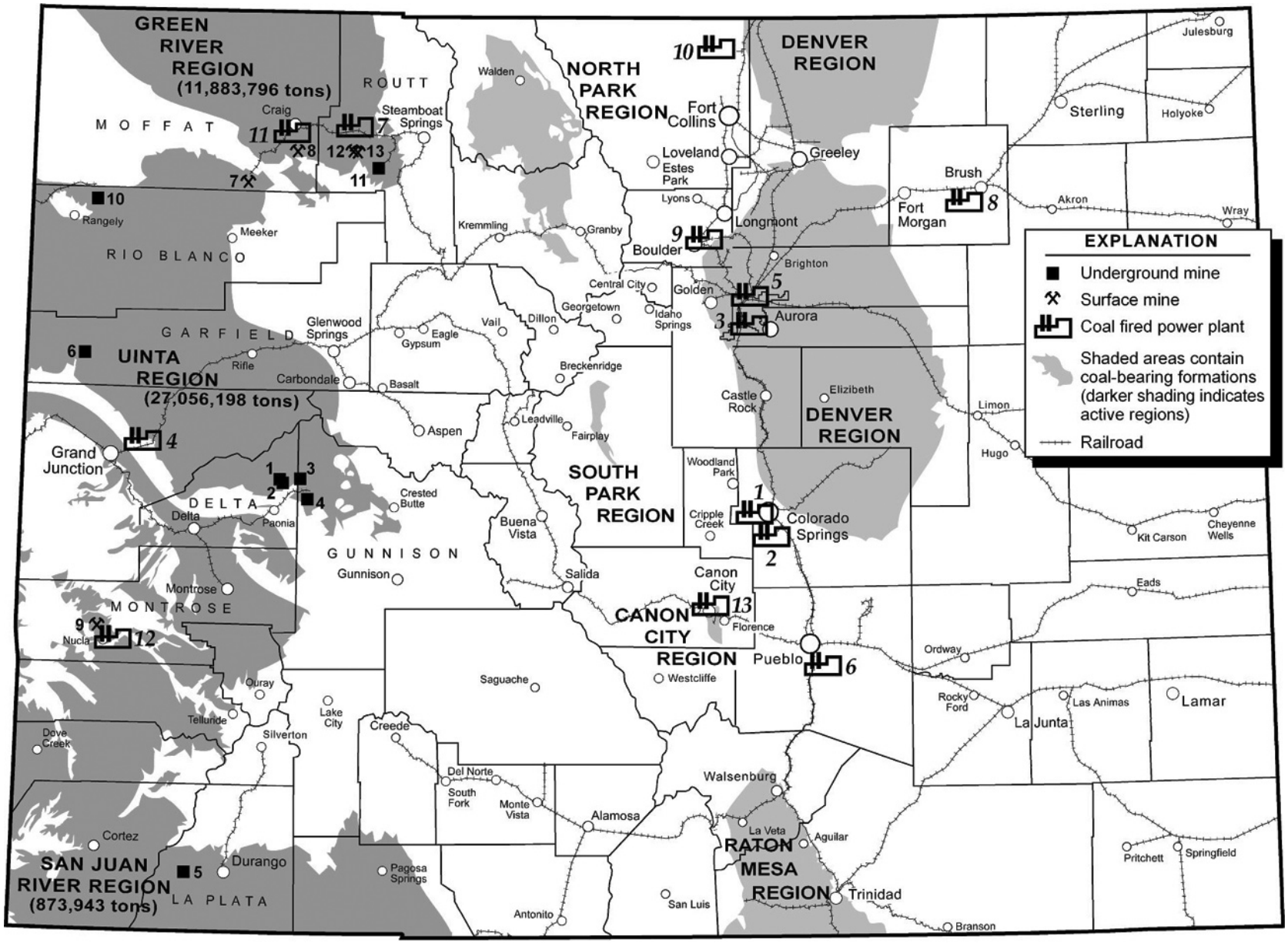

Figure 31. Locations of coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2004. See table 5 for mine information, and table 8 for power plant names.

Table 6. Colorado coal production by county, type of production, and employment as of December 2004. All coal production in tons. Source: Colorado Division of Minerals and Geology.

County	Total Production (tons)	Underground Production	Surface Production	Miners Employed	Mines (Surface/ Underground)
DELTA	4,696,067	4,696,067		214	0/2
GARFIELD	289,495	289,495		22	0/1
GUNNISON	13,140,217	13,140,217		589	0/2
LA PLATA	460,609	460,609		54	0/1
MOFFAT	8,216,648		8,216,648	380	2/0
MONTROSE	413,332		413,332	21	1/0
RIO BLANCO	2,552,762	2,552,762		151	0/1
ROUTT	10,046,794	8,557,745	1,488,949	474	2/1
TOTALS	**39,815,924**	**29,696,895**	**10,118,929**	**1,905**	**5/8**

The 40-million-ton annual production level for Colorado should be sustainable into the immediate future. This is because of new technologies in the mining sector, such as the Addcar Highwall miner used at Colowyo Mine; the Elk Creek longwall operations with new state-of-the-art equipment; and Peabody Energy purchasing the Twentymile/Foidel Creek Mine and increasing output to record levels. Almost all of the coal mines in Colorado had record coal production and sales in 2004.

Exploration

For the first time in many years, coal companies have been actively exploring for new resources in Colorado in 2004. Increased numbers of coal exploration permits have been filed through the Colorado Division of Minerals and Geology offices in the last year. Several companies are conducting exploratory drilling on their existing leases to extend operations, including Bowie, Elk Creek, Twentymile, and Deserado. National King Coal, Central Appalachia Mining, and Colowyo Coal are planning exploration programs. Most recently, two exploration permits have been filed in southern Colorado to explore in the Canon City Coal Region and the Raton Mesa Coal Region (see fig. 31). Northfield Partners, LLC is exploring a site called Northfield in Fremont County, which is north of the Energy Fuels Southfield Mine that closed in 2001. In Las Animas County, the A.P. Maxwell Development Company is exploring the possibility for an underground development project at the Lorencito property.

Radar Acquisitions Corp and its development team, which includes Kiewit Mining Group and Black Hills Generation Power, completed an in-fill drilling program of 31 drill holes at their Buick Project near Agate and Limon, Colorado. The purpose was to verify and evaluate areas drilled in the 1970s for coal quality and reserve estimates. The lignite coal reserves cover an area in excess of 22,000 acres and are estimated to contain 250 million tons of coal in the lower Laramie Formation. The partners are evaluating the potential for a mine-mouth power plant in the area.

Distribution and consumption

Distribution

The main transportation method for coal in the West is by railroad. Both the Union Pacific and the Burlington Northern Santa Fe railroads transport coal through Colorado. The Union Pacific Railroad moves most of the coal out of western Colorado. Over 77 percent of all rail shipments originating in Colorado are coal products. Over 51 percent of the rail shipments terminating in Colorado are coal, by far the single most important rail commodity in the state. Coal rail shipments on a national level are expected to continue increasing.

The constraint of the existing rail infrastructure in Colorado is a limiting factor for coal. In 2004, over 17.4 million tons of coal moved from the Somerset Coal Field to the Front Range and further east. Stockpiles at the three mines were at times, over one half million tons each because not enough rail cars were available. In 2004, over 30 million tons of coal were transported through the Moffat Tunnel between Winter Park and Denver.

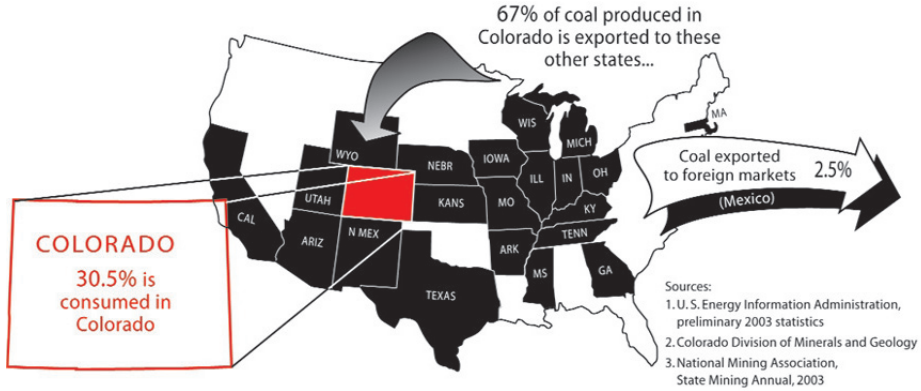

Figure 32. Distribution of Colorado coal, 2003. Source: EIA, 2003 most recent data.

Less than one-third of the coal produced in Colorado is consumed in state. Most is shipped by rail to midwestern and southern states (fig. 32) where it is blended with higher sulfur, eastern coals to reduce pollution in power plants. The leading Colorado coal exports were to Kentucky, Tennessee, Texas, Mississippi, Utah, and Illinois (table 7). Over 9 million tons of coals were shipped to power plants in the Kentucky and Tennessee area in 2003, mostly for the Tennessee Valley Authority. West Elk Mine supplies power plants in Mississippi with more than

2.4 million tons annually, and has now shipped coal as far east as Boston. Over 4 million tons of industrial and commercial coal are shipped to Texas, Illinois, Arkansas, and Iowa for cement manufacturing and other industrial uses.

Colorado also imports coal. Over 9.3 million tons of coal were imported from Wyoming to power plants along the Front Range in 2003 (EIA coal). The Platte River Power Authority's Rawhide Plant in northern Colorado is close to the Wyoming border and uses only Powder River Basin coal. Five other plants from Denver to Pueblo and Brush also use imported Wyoming coal. Over 23,000 tons of anthracite were imported from Pennsylvania in 2003, mostly for industrial plants, but some was for residential and commercial sectors.

About half of the coal trains transiting through Colorado are from Wyoming. According to Burlington Northern Santa Fe (BNSF) personnel, about 40 million tons of coal are transported through Colorado from the Powder River Basin each year. Of this total, about 10 million tons are consumed at Colorado and nearby Kansas and Nebraska power plants. The remaining 30 million tons pass through the Front Range from Fort Collins to Pueblo and Las Animas on its way to Texas and several other southern states.

Table 7. Distribution of Colorado coal to other U.S. states. *Source: EIA 2003 (most recent data available).*

State of Destination	Electric Utilities (Steam coal)	Coke Plants	Industrial Plants	Residential/ Commercial	Total (Short tons x 1000)	Percentage of Total Distribution	Change from 2002	Transportation
Arizona	570	0	115	0	685		down	Rail, truck
Arkansas	0	0	294	0	294		up	Rail
California	0		16	0	16		up	Truck
Colorado (in-state)	10,581	0	96	268	10,945	30.5%	down	Rail, truck
Georgia	359			0	359		up	Rail
Illinois	1,215	0	413	0	1,628		down	Rail
Iowa	277	0	286	3	566		up	Rail, truck
Kansas	57	0	94	0	151		down	Rail
Kentucky	5,237	0	90	0	5,327		up	Rail
Massachusetts	21			0	21		up	Tidewater pier
Michigan	993		109	0	1,102		up	Rail, Great Lakes
Mississippi	2,420	0		0	2,420		down	Rail
Missouri	-	0	134	0	134		down	River
Nebraska	0	0	125	5	130		up	Rail
Nevada	99	0	0	0	99		down	Rail
New Mexico	0	0	79	1	80		up	Truck
Ohio	333	0	0	0	333		down	Rail
Tennessee	3,738	0	0	0	3,738		up	Rail
Texas	2,078	0	1,275	0	3,353		up	Rail, truck
Utah	2,036	0	0	0	2,036		down	Rail
Wisconsin	1,426	0	0	0	1,426		down	Rail, Great Lakes
Wyoming	0	0	149	0	149		up	Truck
Domestic distribution to other states	**20,859**	**0**	**3,179**	**9**	**24,047**	**67.0%**	**up**	
Total Domestic (including Colorado)	**31,440**	**0**	**3,275**	**277**	**34,992**	**97.5%**	**up**	
Foreign Exports to Mexico	**-**	**0**	**898**	**0**	**898**	**2.5%**	**up**	
Total Domestic and Foreign Export	**31,440**	**0**	**4,173**	**277**	**35,890**	**100.0%**		

All figures in thousands of short tons.

Note: EIA total reflects coal transportation inventories, 2003. Represents most current published data, http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/o_co.html

Consumption

A total of 18.9 million tons of Wyoming and Colorado coal were consumed at power plants in Colorado in 2004 (table 8), which is about 97.5 percent of Colorado's coal consumption. Over 37.5 million megawatts (Mw) of total power were generated by Colorado coal-fired plants. Some of these plants also use natural gas or fuel oil as additional power sources. The use of coal for fuel is higher than in 2003; natural gas is lower. This is because of the increased cost of natural gas.

Xcel Energy owns or operates seven coal-fired power plants in Colorado and is the largest utility consumer of coal in the state. The Cherokee Station in Denver produced 5.4 million megawatt-hours of electricity last year, consuming 2.22 million tons of coal and 462,000 thousand cubic feet of gas. The plant gets coal from the Twentymile and Colowyo mines in northwest Colorado.

In December 2004, the Public Utilities Commission approved Xcel Energy's plan to obtain 3,600 Mw of new generating capacity by 2013. Xcel plans to build a new coal-fired unit onto the existing Comanche Power Station in Pueblo. This will be the first new coal-fired electrical generating facility built in Colorado since 1985.

Colorado voters approved Amendment 37 in November 2004, which requires utilities to get a portion of their retail electricity sales from renewable energy such as wind, solar, or biomass. Starting in 2007, three percent of the electricity sales must come from these sources. Xcel Energy and its wind energy partners already have 230 Mw of total wind generating facilities, and would like to build an additional 500 Mw of wind power. Xcel is currently negotiating with wind power companies to build another 87 windmills and triple its wind energy output. In 2004, Xcel Energy purchased about 652,000 Mw-hours of wind-generated energy from its wind power partners in Colorado and produced another 65,000 Mw-hours at its Ponnequin wind farm.

Table 8. Electric generation and fuel consumption at coal-fired power plants in Colorado, 2004. List does not include major gas plants or small coal generation facilities. Refer to Fig. 31 for map locations. PRB = Powder River Basin, Wyoming. Data from utility company annual reports.

Map No.	Power Plant	Utility	Nameplate rating	Gross Electric Generation (Mw)	Coal (tons)	Gas (MCF)	Fuel Oil (BBLS)	Origin of Coal
1	Martin Drake	Colorado Springs Utilities	281	1,830,722	872,564	220,886	-	70% Foidel Creek, 30% Wyoming PRB
2	Nixon	Colorado Springs Utilities	225	1,865,968	991,696	73,919	118,218	Wyoming PRB
3	Arapahoe	Xcel Energy (partly gas)	144	987,184	604,636	19,406	-	Wyoming PRB
4	Cameo	Xcel Energy	66	471,707	295,601	35,488	-	McClane Canyon Mine
5	Cherokee	Xcel Energy	710	5,400,031	2,227,080	462,443	-	99 % Foidel Creek Mine, 1% Colowyo Mine
6	Comanche	Xcel Energy	700	4,720,155	2,606,392	120,875	-	Wyoming PRB
7	Hayden	Xcel Energy/Pacif-corp/Salt River Project	447	3,797,560	1,813,067	14,270	1,957	99% Seneca Mines, 1% Foidel Creek
8	Pawnee	Xcel Energy	547	3,760,418	2,182,976	94,748	-	Wyoming PRB
9	Valmont	Xcel Energy	166	1,433,818	588,140	19,711	-	73% Foidel Cr, 26% Colowyo, 1% Elk Cr
10	Rawhide	Platte River Power Auth.	270	2,252,742	1,296,357	310,694	65,253	Wyoming PRB
11	Craig	Tri-State G & T Assn.	1264	9,969,190	4,889,228	67,562	314,362	58% Colowyo, 39% Trapper, 3% Foidel Cr
12	Nucla	Tri-State G & T Assn.	100	747,743	418,744	-	-	New Horizon Mine
13	W.N. Clark	Aquila Inc.	38	285,000	160,000	-	-	Foidel Creek Mine
	State Totals		**37,522,238**	**18,946,481**	**1,440,002**	**499,790**		

Coal consumption in Colorado is mostly for electrical generation, but about 2 percent is consumed in the manufacturing and commercial sectors. Major manufacturers using coal for boilers in Colorado include Cemex, Inc. and Holcim, Inc. for cement-manufacturing; Txi, Inc. for light weight shale aggregates; Western Sugar for their sugar beet refining; and the Coors Brewery for beer manufacturing.

Employment, safety, and productivity

Coal is the biggest component of Colorado's mining industry today. Employment in the coal industry was up in 2004 (fig. 28). The number of miners employed by Colorado coal companies increased nine percent to 1,905—a 14-year employment high. This increase in employment is a result of the increased production at the large coal mines.

According to the Colorado Mining Association, individual miner's wages and benefits in Colorado exceed $76,000 annually. They are the highest paid industrial workers in the state. Union miners account for 22 percent of Colorado's coal mining workforce. This level is expected to remain unchanged in 2005.

Colorado's coal miners produce more coal per man-hour than most other states. Coal mining productivity is defined as the total state coal production divided by the total direct labor hours worked by all mine employees. In 2003, the average production per miner-hour was 8.6 tons—up 3.7 percent from 2002 (EIA coal data). Underground miners in Colorado produced at a rate of 9.14 tons per miner-hour—the second highest rate in the nation.

The U.S. Department of Labor's Mine Safety and Health Administration (MSHA) reports that 2004 was a year for the least amount of mining fatalities nationally. There were 54 mine fatalities in coal and mineral/non-mineral mines last year. Of these, 28 were coal mine fatalities, the second lowest total ever recorded. In Colorado coal mines, no fatalities have occurred in over four years, which is a tribute to the individual mines safety programs and the Division of Minerals and Geology's Mine Safety and Training Program.

At the Colorado Mining Association's 106th National Western Mining Conference in February 2005, several coal companies and contractors won safety awards. Mountain Coal's West Elk Mine was awarded the large underground coal-excellence in safety award for its efforts in reducing their lost-time accident rate from 6.67 in 1999 to 2.14 in 2004. Their injury-severity rate dropped from 62 percent in 2003 to 31 percent in 2004. Bowie Resources, LLC accepted an award for the large underground coal-excellence in safety award for the Bowie #2 Mine. The company worked 424 days without a lost-time accident. Bowie also reduced their total lost-time incident rate from 3.67 in 2003 to 1.54 in 2004.

As for the large surface mines, Trapper Mine won the top safety award for excellence in safety award. The mine worked over 549 days without a lost-time accident. Kennecott Energy Company and the Colowyo Mine won the surface coal mine award for their achievement in adoption and implementation of an employee-driven safety program to support continuous improvement in safety performance. Employees suggest changes to the safety plan based on continual update and implementation.

The 2004 Longwall Census from *CoalAge* Magazine (Feb. 2005) reports five active longwall machines in Colorado (table 9). Nationally, 46 mines operate 52 longwall faces. The total length of Colorado's average longwall faces (over 10,000 feet long) is much greater than the U.S. average. According to *Coal Age,* the 52 longwall faces operating today have increased productivity and capacity, but may have peaked. The average U.S. longwall cutting height measured 84 inches, panel width is 922 feet, and average panel length is 9,724 feet. The average rating for the shearer is 1,295 horsepower; the average yield is 870 tons. In terms of worker productivity, EIA reports that Colorado's longwall miners were the second most productive in the nation for 2003, producing 9.48 tons produced per miner-hour.

Table 9. Colorado underground longwall mining statistics. Source: *Coal Age*, Feb. 2005.

Company Name (Mine)	Seam	Seam ht. (inches)	Cutting Ht. (inches)	Panel Width (feet)	Panel Length (feet)	Overburden (feet)	Depth of Cut (inches)	Shearer
Bowie Resources (Bowie Mine #2)	D	108–120	96–120	845	7,000	1,100	36	DBT America DDR 2,060
Blue Mountain Energy (Deserado)	B	84–168	132	800	11,000	400–900	32	Joy 4LS-5 DDR 1,030
Oxbow Mining (Elk Creek)	D	108–180	132	805	6,800	500–2,000	30	Joy 7LS-3A DDR 1,720
RAG American Coal (Foidel Creek)	Wadge	96–114	96–114	1,000	12,000–15,000	600–1,400	36	DBT America DDR 1,920
Arch-Mt Coal Co (West Elk)	B	276	144	950	3,500–9,000	600–1,400	40	Joy 6LS-2 DDR 1,720

Coal quality and reserves

Coal quality

There are four basic types of coal: anthracite, bituminous, subbituminous, and lignite. These coal rankings are determined by physical characteristics such as hardness, density, heat value, and luster. Anthracite is the hardest coal with the highest heat values and luster or vitrinite properties. It has heat values that range from 12,000–14,000 British thermal units (Btu). Lignite is at the other end of the spectrum—less dense, dull luster, with heat values less than 7,000 Btu. Colorado coal ranges throughout this spectrum, but is mainly bituminous and sub-bituminous. These resources constitute the main mineable coal for electrical-generating needs. The only anthracite reserves are in the Crested Butte area. The Denver Basin contains subbituminous and lignite resources.

How much energy is in coal?

The amount of energy given off by coal is defined by the heat value measured in British thermal units, or Btu's. This is the amount of heat energy it takes to raise the temperature of one pound of water by one degree Fahrenheit at sea level. One Btu is about equivalent to the amount of energy in a single match. Five pots of coffee could be brewed with one pound of Colorado coal.

Four components are important in determining whether a certain coal is highly desired or less desired: ash, sulfur, mercury content, and the heat value (Btu). These, along with transportation costs, determine the price that can be obtained for a particular coal. The amount of ash determines how much impurities such as clay particles are mixed in with the coal. The lower the ash content, the lower the waste products after burning. The amount of sulfur and mercury determines how much removal treatment is required to meet Clean-Air Standards. The Btu value determines how much heat can be generated with a pound of coal. The average coal mined in Colorado today is 10,952 Btu, 0.6 percent sulfur, and 10.55 percent ash. This is characterized as a high energy, moderate ash, and low sulfur coal. Colorado is second only to Illinois in bituminous coal reserves, but is by far the leader in bituminous compliance coal reserves.

Colorado steam coal is attractive because of its high quality for compliance with power plant emission standards (table 10). The San Juan and Raton Mesa Coal Regions have the highest heat values, averaging well over 12,500 Btu. The Denver Coal Region has the lowest sulfur coal averaging 0.3 percent. South Park and Uinta Coal Regions have less than 7 percent ash. Colorado coal produced in 2003 ranges between 0.4 and 0.8 percent sulfur, which is about two or three times lower than the average eastern bituminous coal. The average quality of coal received at electric utilities in Colorado is compliant with Clean Air Act standards.

Table 10. Average quality values for minable coal beds from all coal mines in Colorado by coal region. Source: CGS Information Series 58. Mercury values from the U.S. Geological Survey's National Coal Quality Inventory at active mines in 2001.

Analyses	Denver Region	Green River Region	North Park Region	Raton Mesa Region	San Juan Region	Uinta Region	South Park Region	Canon City Region
Ash (percent)	11.2	9	12.4	16.1	12.7	6.8	6.4	9.8
Sulfur (percent)	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 emissions from coal-fired boilers are an upcoming Environmental Protection Agency (EPA) issue for air pollution control. On March 15, 2005, the EPA ruled on the amount of toxicity allowed in the air for coal-fired generators. This will be the first ever proposed on power plants. Mercury is a common trace element in coal and during combustion it volatizes to elemental mercury vapor. As the flue gas cools, the mercury converts to ionic mercury compounds of gaseous and solid phases that are adsorbed onto other particles. Mercuric chloride is common, but many species of mercury develop which makes control equipment difficult to choose. Generally, the mercury produced in bituminous coal-fired boilers is gaseous ionic mercury, but in subbituminous and lignite boilers, it is elemental mercury vapor.

Processes that remove particulate matter achieve favorable levels of mercury emissions. Fabric filter units remove the most mercury. Other pollution control techniques include cold and hot side electrostatic precipitators, and particle scrubbers. In general, more mercury is removed from bituminous coal than subbituminous coal. Activated carbon injection technology can achieve high levels of mercury control. According to the EPA, only one percent of global mercury emissions come from U.S. power plants.

Reserves

About 75 percent of Colorado coal leases are federally owned. Nearly 50,000 acres are currently under lease. For 2003, EIA reported that Colorado had 424 million tons of recoverable coal reserves under lease at active mines—a 32 percent decrease over 2002. The EIA's Demonstrated Reserve Base (DRB) data show Colorado with 16.365 billion tons of minable coal (fig. 33)—11.6 billion tons underground minable and 4.76 billion tons surface mineable. Recoverable reserves are defined as that part of the DRB that can be mined using today's mining technology.

The Colorado Geological Survey is interested in determining just how much coal remains in reserve underground today. Future assessments of our needs are difficult, but a few assumptions can be made. Over the past 20 years, annual coal production has increased two percent per year. If we project that rate into the future, Colorado will have annual coal production that doubles to 80 million tons per year in 400 years. That doesn't sound like much, but if we calculate how much total coal we extract in that time, we will have exhausted the current estimate for the DRB of 16.4 billion tons.

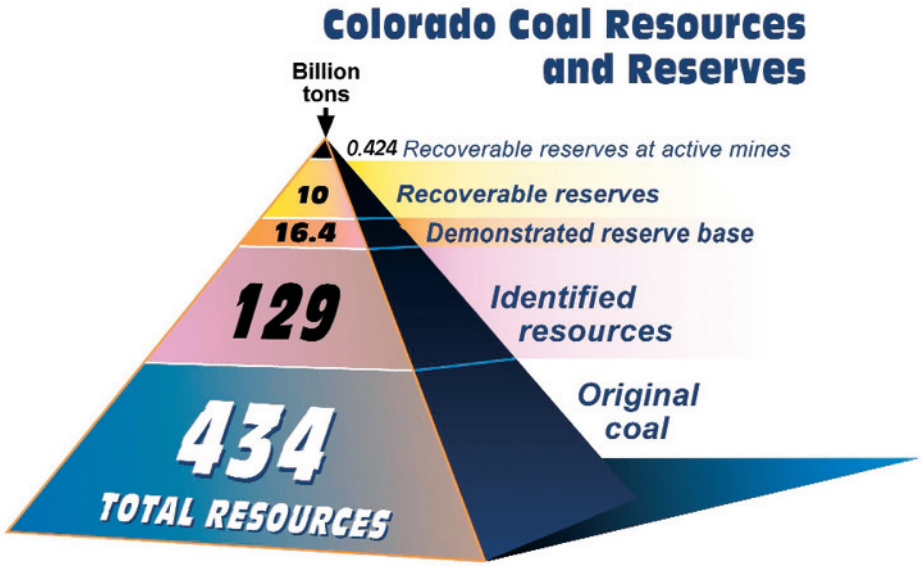

Figure 33. Diagram of coal resources and estimated reserves. Source: U.S. Dept of Energy, EIA.

Colorado Coal Mine News

Northwest Colorado coal mining news

Peabody Energy completed their purchase of the Twentymile/Foidel Creek Mine in Routt County from RAG American in 2004. Peabody Energy now owns the three active coal mines in Routt County. Twentymile/Foidel Creek Mine produced 8,557,745 million tons of coal in 2004—a new single mine annual production record in Colorado. EIA lists Foidel Creek Mine as the third largest underground mine in the nation in coal production (EIA 2003 data).

According to *Paydirt* Magazine, Peabody Energy plans to close its Seneca mines near Hayden (Yoast and Seneca II-W) by the end of 2005. These surface mines have endured problems mining the steeply dipping coal seams for several years now. The coal beds are less than economic now because the coal layers dip up to 27 degrees at the Seneca II-W Mine (fig. 34). These two surface mines remove the Wadge and Wolf Creek coal seams of the Williams Fork Formation. The Wadge seam is one of the nation's top producing coal seams, varying in thickness between 108 and 150 inches thick (EIA 2004 data). The Seneca coal mines have supplied the Hayden Power Plant since 1964 and more than 42 million tons of coal has been mined from the Seneca, Seneca II, Seneca II-W, and Yoast mines.

Figure 34. Aerial oblique photograph of the Seneca II-W surface activities, 2004. *Photo courtesy of Sandy Brown, DMG.*

Peabody Energy and Xcel Energy are negotiating contracts to meet the new coal distribution needs at the Hayden power plant through 2011. Peabody plans to supply the plant in the near future with coal from the nearby Twentymile/Foidel Creek Mine. The haul truck operation will cease when Seneca closes, and be replaced by train loadings from Twentymile Mine. Peabody may increase the production at the Twentymile Mine by 50 percent in the next three years. Twentymile could be producing 12 million tons per year by 2006, making it one of the largest underground coal mines in the nation. A new loading facility from the train to the power plant must be built to accommodate the plan.

Trapper Mining Company reports that in 2004, the company had 13 percent more coal sales to the Craig Station power plant than in 2003. The mine is currently operating in the eastern part of their lease area.

The thicker coal beds (fig. 35) that have been mined in the past have split in the eastern direction, making coal recovery more difficult. This is a problem for the dragline to remove the overburden because it is more difficult for the dragline to have a place to sit. Trapper Mine has designated a bulldozer fleet to assist the dragline with overburden removal. Leading the fleet is Trapper's new purchase, a Caterpillar D-11 Dozer, now the largest in their fleet. This bulldozer, along with the D-9 and D-10 dozers they already have, can move the overburden with more efficiency than the dragline in thin coal bed conditions. Ironically, although the seams are thinner, they are also split so that Trapper can now recover some of the thinner, previously spoiled seams. This increases the reserve base as additional seams are added to the recovery. There are another nine years of surface reserves currently on the property. Trapper is also implementing an underground exploration program over the next few years to look for the Middle Coal Group coals, beneath their lease boundary.

Figure 35. Thick coal beds of the Upper Coal Group of the Williams Fork Formation at the Trapper Mine, 2000.

The Colowyo Mine in Moffat County is the state's largest surface coal mine. In 2004, the mine produced 6.38 million tons of coal—a 22 percent increase over their 2003 production of 5 million tons. This is due in part to new contracts, and in part to their new ADDCAR Highwall Mining System. Colowyo is exploring their Collum Lease area for future mining operations. In 2004, the company drilled over 100 exploration holes to evaluate the potential of future surface and underground reserves.

The Deserado Mine in Rio Blanco County near Rangely produced 2.55 million tons of bituminous Mesaverde Group coal in 2004. This was a record production year for the mine. Mine personnel report that the large channel claystone which truncated their coal seam in 2004 is not present in their current and future mine area. The mine is owned and operated by Deseret Power of Utah to supply the Bonanza Power Plant, 34 miles west of the mine. Coal is washed and then conveyed to a train load out. Deserado drilled two exploration holes to the north in 2004 along the Red Wash Anticline.

Somerset coal field news

Oxbow Mining Company's Elk Creek Mine was fully operational in 2004. The mine established two production records in 2004: a monthly record of 719,352 tons (July), and an annual production record of 6,549,024 tons. Elk Creek Mine is now one of the leading underground mines in the nation in terms of worker productivity. The miners work two shifts per day and fill two unit trains per day. Currently they are mining 350–1,800 feet below ground. As of March 2005, the last panel in the Gunnison County part of the mine was being recovered. Future mining will mainly be in Delta County, as the area west of Bear Creek is developed. Although the mines experienced coal train haulage problems in 2004, difficult mining conditions of late have enabled Elk Creek to dwindle their stockpile in 2005. Elk Creek Mine has an estimated 53 million tons in reserves through 2014 in the current mine plan.

Arch Coal's West Elk Mine on the east end of the North Fork Valley had another excellent year. Coal sales were up and production was again over 6.5 million tons in 2004. The mine set an all-time monthly production record in January 2004 with 855,602 million tons produced. West Elk mines coal in the B-seam and the E-seam of the Mesaverde Group. They longwall mine the B-seam, which is one of the nation's top-producing coal seams with an average thickness of 161 inches (EIA, 2004 data). In 2004, the mine began development in the E-seam. By 2008, they will move the longwall into the E-seam in the southern part of their lease near Minnesota Reservoir. This coal is very low sulfur coal with less cover than the B seam and about 15 years of reserve. Arch is pursuing the Dry Fork lease area south and east on the E-seam reserve. West Elk Mine still uses a series of gas vents to re-direct methane gas from the longwall face. West Elk Mine produces a good

high premium steam coal product that has some of the nation's lowest mercury concentrations.

Bowie Resources produced from two mines in 2004. The main production was from the Mesaverde D coal seam at Bowie #2 Mine. The longwall is completing its last panel in the West Mains section of the mine. The mine is scheduled for closure by the end of the year. The longwall will be moved into the Bowie #3 Mine soon. Bowie #3 was developed with conventional mining during 2004 along the Mesaverde B coal seam. Once the longwall is in place, production is expected to resume at the usual 5 million tons per year rate. Bowie constructed a new preparation plant in 2004 (fig. 36). Bowie personnel foresee new customers opening a new market place for their coal. Strong demand and pricing is the future, and railroad capacity is still a concern for them and the other mines from the Somerset Coal Field.

Southwest Colorado coal mining news

National King Coal's 68-year old mine near Durango set a new coal production record in 2004 with 460,611 tons produced. Sales of coal to cement plants picked up as the mine now markets coal to northern Mexico. The high-Btu and low-ash coal makes for very good cement manufacturing. The existing mining operation should still be viable for the next four years. The future mine in the East Alkali Gulch tract should increase their reserves for 25 more years. Originally opened in 1936, King Coal is Colorado's oldest and longest continually operating coal mine, having produced over 5.2 million tons of coal from the Menefee Formation of the Mesaverde Group.

The New Horizon Mine in Nucla, Colorado, also set a new annual coal production record in 2004. The surface mine produced 413,332 tons in 2004. New Horizon is a captive mine-mouth operation for Tri-State Generation and Transmission's fluidized bed Nucla Power Plant. This is a 100 megawatt plant that was the world's first circulating fluidized-bed combustion power plant when retrofitted in 1987. The New Horizon Mine has supplied the plant with over 4.2 million tons of coal since 1993. This is the only coal mine in the state producing coal from the Dakota Group. There are two main coal beds—the #1 bed (less than two feet thick) and the #2 seam, which is 5 to 7.5 feet thick.

Figure 36. Construction of the new preparation plant (before walls) for the Bowie Resources Mines near Paonia, Colorado, August 2004.

NONFUEL MINERALS AND URANIUM

Summary

CGS estimates that the total value of nonfuel minerals produced in Colorado in 2004 is $949 million. This estimate is compiled from information obtained by CGS from mine operators, news articles, corporate press releases, and annual reports of public companies. Additional information was obtained from the U.S. Geological Survey (USGS) Minerals Information Team. The estimated 2004 production value is a 35 percent increase over the revised 2003 value of $702 million and is the highest since 1982. Nonfuel mineral production in Colorado includes metals, industrial minerals, and construction materials such as crushed stone, sand, and gravel. The USGS ranked Colorado 22nd among the 50 states in production of nonfuel minerals in 2004.

The large increase in production value in 2004 is mainly due to increased production of molybdenum and gold combined with sharply higher prices for those metals. Figure 37 shows the value of nonfuel mineral production in Colorado from 1977 through 2004. Figure 38 shows the relative contribution of the various commodities to the total production value of nonfuel minerals in 2004. Figure 39 is a map of the major metal and industrial mineral mines that are presently active in the state.

Mineral exploration and development activity increased in 2004. In Colorado, the number of active, unpatented mining claims on public lands has generally been declining since 1994, but 2004 showed a modest increase compared to 2003 (fig. 40).

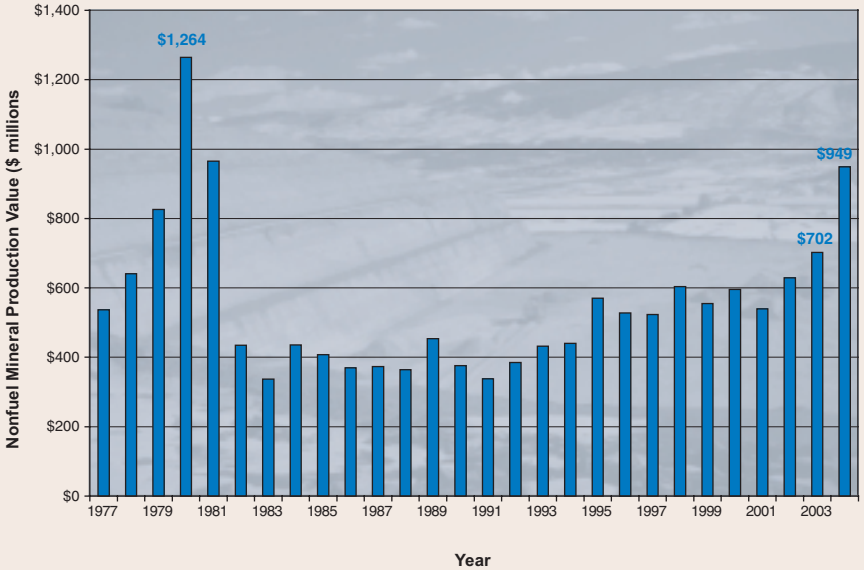

Figure 37. Colorado nonfuel mineral production value, 1977 to 2004. The spike around 1980 was largely due to high molybdenum production at both the Climax and Henderson mines, and high molybdenum prices.

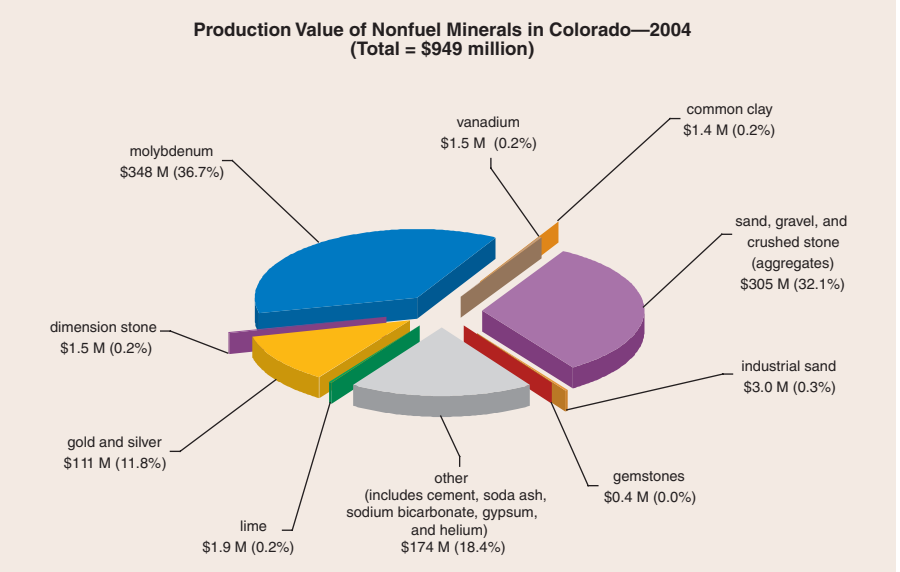

Figure 38. Relative value by commodity of nonfuel mineral production in Colorado, 2004.

Metal Mining

Globally, the metals mining industry is enjoying its first boom of the 21st century. Continuing the trend that began in 2002, prices for all of the metals produced in Colorado rose significantly in 2004. In Colorado, the raw monetary value of metals mined rose 96 percent compared to 2003 as production and prices increased. Colorado is the 3rd leading gold-producing state in the U.S. and is ranked 2nd in molybdenum production. It is the only state currently producing vanadium ore and is one of the few states that produces uranium.

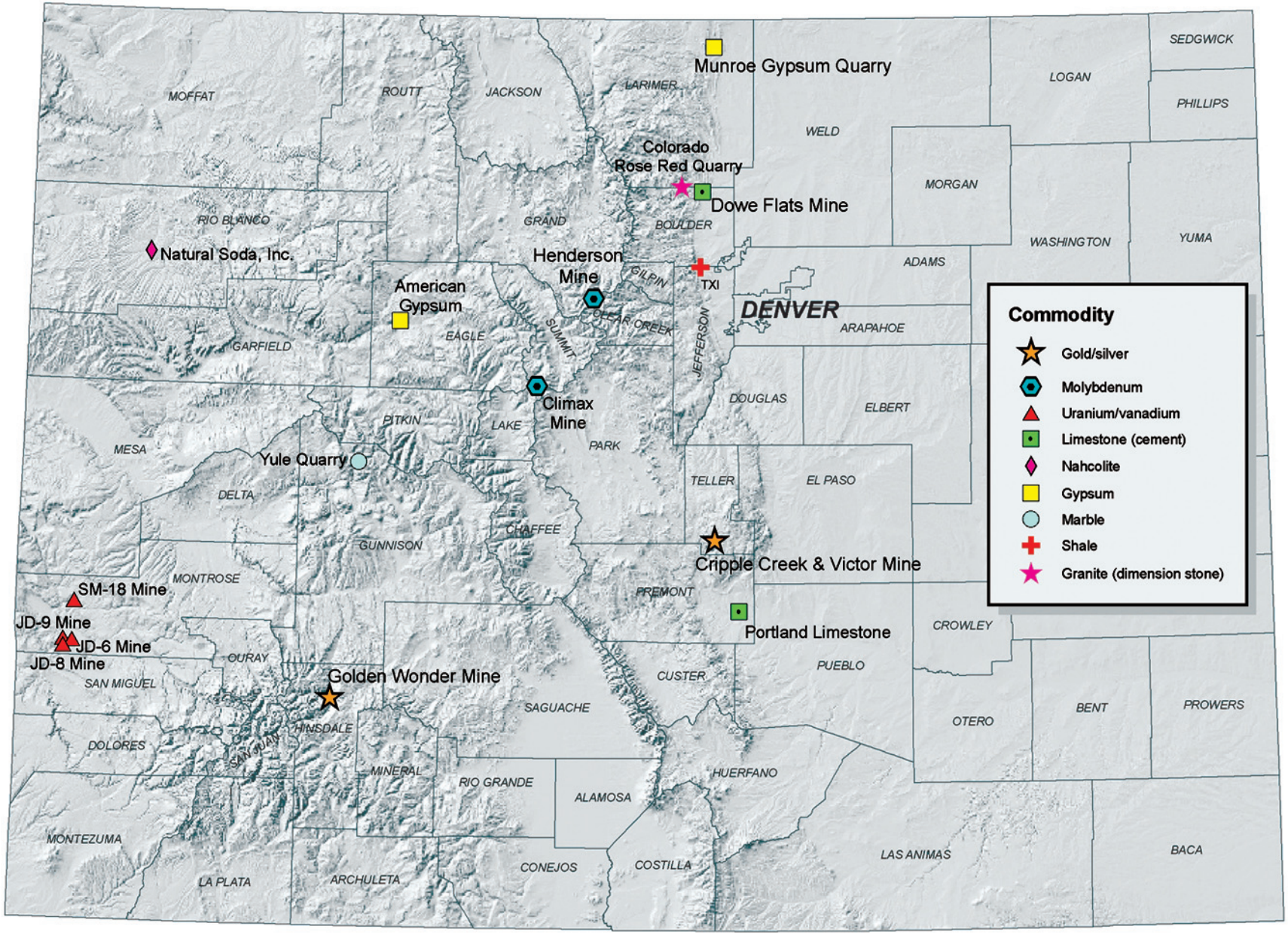

Figure 39. Map showing the locations of significant mining operations in Colorado as of early 2005. Coal, sand, gravel, crushed stone, and clay mines not shown.

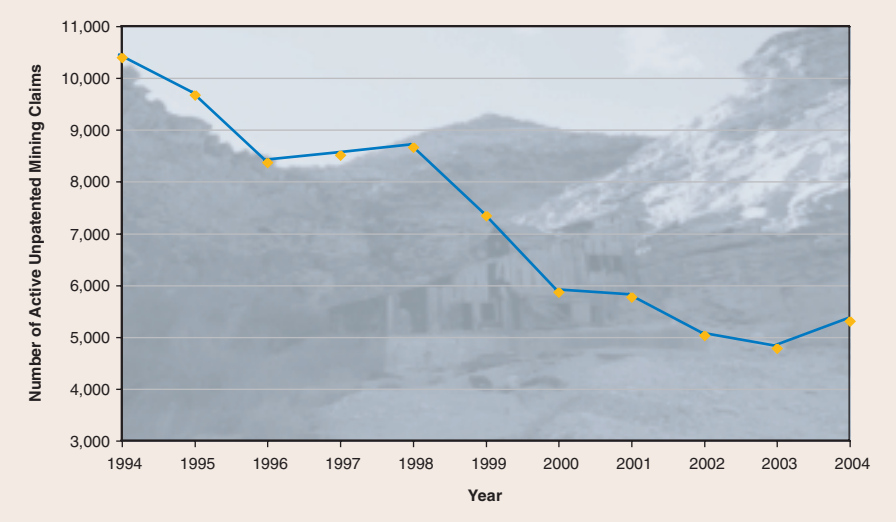

Figure 40. Active unpatented mining claims in Colorado, 1994–2004. Source: U.S. Bureau of Land Management; active claims on file at end of year.

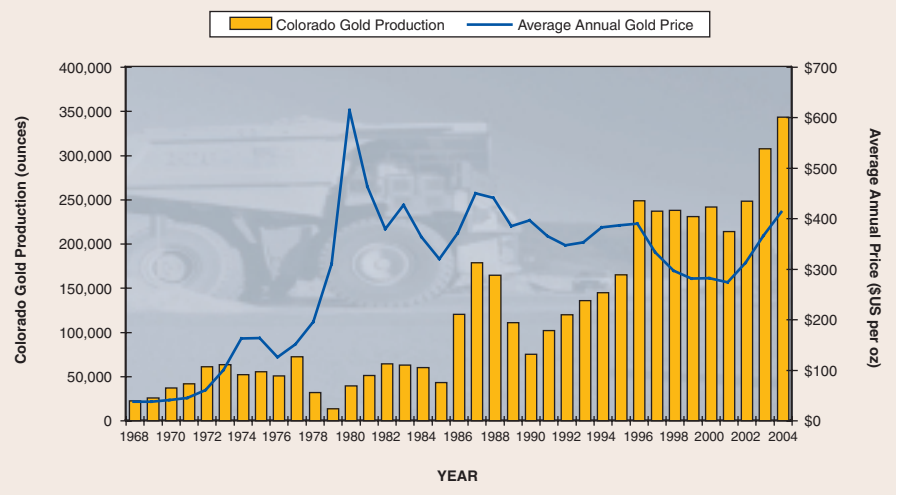

Figure 41. Colorado annual gold production and average annual gold price, 1968–2004.

Worldwide, metal price increases have greatly stimulated exploration and development of new and dormant deposits. The current price boom is fueled largely by steadily increasing demand from China and India, both of which are rapidly industrializing. Many mining industry leaders expect the current boom to last for at least the next ten years. The annual survey for nonferrous metal exploration expenditures shows that exploration budgets in 2004 totaled about $3.55 billion, the highest since 1997 and nearly double the $1.9 billion spent in 2002 (source: Metals Economics Group).

Gold and silver

Gold and silver are precious metals that played a leading role in the early history and economy of Colorado, and they are still being mined in the state. In fact, gold production has been increasing significantly in Colorado in recent years (fig. 41). Gold is used in jewelry, and bullion is held as an investment. Gold also has numerous industrial and medical applications. Gold has superior electrical conductivity, resistance to corrosion, and other physical and chemical properties that make it an exceptionally useful metal. The main industrial uses for gold are in electronics and as an electrolyte in the electro-plating industry (MII, Minerals Information Institute). The largest medical use for gold is as a dental filling. Silver, like gold, is used mostly for jewelry but also has many other applications including photographic film, dental alloys, medical, and scientific equipment, mirrors, electrical contacts, and in high-capacity silver-zinc and silver-cadmium batteries.

Cripple Creek & Victor Mine, Teller County: AngloGold (Colorado), a subsidiary of South Africa-based mining giant AngloGold Ashanti Ltd., operates the largest precious metal mine in Colorado. The Cripple Creek & Victor (CC&V) Mine is also one of the most productive gold mines in the U.S. It produced 329,030 ounces of gold in 2004, up 16 percent from the 283,000 ounces produced in 2003. The average grade of ore mined was 0.025 ounce of gold per ton. Based on AngloGold's realized sales prices of gold produced at the CC&V Mine, the value of gold produced at the mine in 2004 was $105 million. The spot gold price averaged $409.73 per ounce in 2004 (London PM Fix; data from Kitco Inc). Figure 41 shows Colorado gold production and gold price from 1968 through 2004. Over 199,000 ounces of silver, valued at approximately $1.3 million, were also produced. AngloGold expects the mine to produce approximately 330,000 ounces of gold again in 2005. The current reserve base is sufficient to support gold production at least until 2012.

In 2004, CC&V received county and state approval for extending the East Cresson portion of the mine into a new area. The extension will provide approximately 5.5 million tons of additional ore to the existing resource. The company moved the historic Hull City ore sorting house and headframe. The structures will be relocated upon completion of reclamation. CC&V continues to support the Pikes Peak Regional Medical Center and other community services and events. The mine employs approximately 320 people and is the largest private employer in Teller County.

Golden Wonder Mine, Hinsdale County: LKA International Inc. owns the Golden Wonder, a small underground gold mine near Lake City in the San Juan Mountains. Production in 2004 was 14,320 ounces of gold. The weighted average grade of ore mined during the last two years was 15.26 ounces of gold per ton. In January 2005, LKA announced that it is planning to permit and develop a new adit and drift below the current workings. The proposed drift will be located approximately 1,000 vertical feet below the deepest current workings. The horizontal distance of the new drift will be approximately one mile and take roughly 18 months to complete. At a cost of an estimated $2 million, the drift is intended to intersect the high-grade vein structure at the deeper level, which will significantly increase the production potential of the mine. Since beginning operations in 1998, the mine has produced approximately 95,000 ounces of gold. High-grade crushed ore from the mine is trucked in "super sacks" (fig. 42) to Barrick Gold Corporation's Goldstrike facility in Nevada for milling and processing.

Figure 42. Loading a "super sack" of high-grade ore to a truck, Golden Wonder Mine, Hinsdale County. Ore from the mine is shipped to Nevada for processing; photo courtesy LKA International, Inc.

Pride of the West Mill, San Juan County: The Pride of the West Mill northeast of Silverton was unable to continue operations in 2004. Extreme cold weather and lack of insulating snow cover in November 2003 resulted in the mill "freezing up" and the operator, Silver Wing Company, was forced to shut it down. Financial difficulties led owner Tusco, Inc. to foreclose on the mill operator in March 2004. As part of its site reclamation activities, Tusco, Inc. operated the mill temporarily in the summer and fall to process low-grade mineralized material from the stockpile of low-grade ore that remained on the site. As of March 2005, the mill was not operating.

Molybdenum

Molybdenum is an important, versatile, and widely used metal. Molybdenum's largest use is as an alloy agent in stainless steel, other specialty steels, and cast iron. It increases hardenability, toughness, corrosion resistance, and weldability of steel. High-temperature superalloys are used in jet engines, among other things. Molybdenum is also used in titanium alloys for products where low weight, high strength and corrosion resistance are important, such high-performance bicycle frames (International Molybdenum Association, IMAO).

When combined with cobalt and nickel, molybdenum is used in the petroleum industry for its ability to remove sulfur from the organic sulfur compounds usually found in crude oil. As the world supply of crude oil is further extended and low-sulfur crude oils become scarce, molybdenum-based catalysts will increase in use. In a similar manner, molybdenum is used in "scrubbers" to remove sulfur from flue-gases. Molybdenite, the soft, shiny, bluish-gray mineral, is widely used as a lubricant to reduce friction between metal parts. Some automotive oils and greases have molybdenum additives.

The price of molybdenum skyrocketed from around $8 per pound at the end of 2003 to over $30 per pound in early 2005. The price rise is attributed to increased demand in China and a tight global supply. The high price has stimulated increased production of the metal. Because of the high price and increased production, molybdenum is now the largest segment of Colorado's nonfuel minerals industry in terms of production value. Figure 43 shows molybdenum production in Colorado and average price per pound of molybdic oxide from 1970 through 2004.

Henderson Mine, Clear Creek County: The Henderson Mine in the Front Range west of Idaho Springs added a work shift and significantly increased molybdenum production in 2004. The large, underground, block-cave mine is owned by Climax Molybdenum Company, a subsidiary of Phelps Dodge Corp. The mine produced 27.5 million pounds of molybdenum metal contained in concentrates, which is a 24 percent increase from the 22.5 million pounds produced in 2003. Phelps Dodge reported that it received an average of $12.65 per pound for molybdenum produced in 2004. The estimated production value is over $348 million. In 2005, Henderson expects to increase production to 31 million pounds. The mine and mill now employs 485 workers.

Ore from the mine is transported to the mill in Grand County by a conveyor belt through an eight-mile-long tunnel under the Continental Divide. At the mill, ore is processed to molybdenite concentrate. The sulfide concentrator at the Henderson mill is capable of treating 32,000 tons of ore per day. The mine ships most of its high-purity, chemical grade molybdenite concentrate to Fort Madison, Iowa, for further processing. Henderson Mine has produced more than 160 million tons of ore and 770 million pounds of molybdenum metal since opening in 1976 and continues to be North America's largest primary producer of molybdenum.

Henderson is currently developing the new 7,210-foot production level, which is expected to produce at a rate of 40 million pounds of molybdenum per year by mid-2006. The 7,700-foot level, which has been the source of most ore production since 1991, is being depleted. Reserves at year-end 2004 were 158.7 million tons with a grade of 0.21 percent molybdenum.

Climax Mine, Lake and Summit Counties: The Climax Mine, also owned by Phelps Dodge, was the first major molybdenum mine in the U.S. It is located on the Continental Divide at Fremont Pass between Leadville and Copper Mountain. Mining was suspended in 1995 and the mine has been on care-and-maintenance since then. Phelps Dodge reports that at year-end 2004, Climax still contained millable reserves of 158.7 million tons of ore grading 0.19 percent molybdenum. High molybdenum prices and projections have prompted Phelps Dodge to evaluate the economic viability of starting up mining operations at Climax for short- and mid-term production. The long-term goal of Phelps Dodge is to restart full operations at Climax when the reserves at the Henderson Mine are exhausted. The mill and concentrator at Climax is capable of processing 16,000 tons of ore per day.

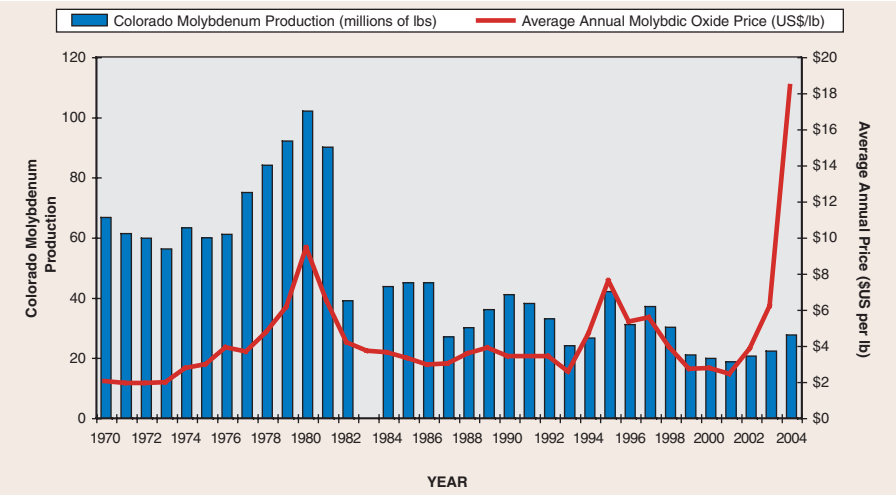

Figure 43. Molybdenum production in Colorado and average molybdenum prices, 1970–2003.

Vanadium

About 90 percent of vanadium is used as a metallurgical agent, primarily as an alloy to strengthen specialty steel. The metal also helps to make steel resistant to corrosion. Vanadium is also used as a chemical catalyst. Colorado is the only state currently producing vanadium ore. Vanadium is a co-product of uranium mining at the recently opened Cotter Corp. mines in Montrose County. Although these mines are known mainly for their production of uranium, they produce more vanadium by volume than uranium. In 2004, Cotter's mines produced 15,210 tons of ore containing at least 281,900 pounds of vanadium. The USGS reports that average prices for vanadium more than doubled in 2004, averaging $5.28 per pound compared to $2.21 per pound in 2003 and $1.34 in 2002. A conservative CGS estimate of the value of vanadium contained in Cotter's 2004 ore production is $1.5 million based on the average 2004 price. Cotter expects to achieve a production of 80,000 tons of ore in 2005 and 140,000 tons in 2006. Ore grades are expected to be 1.84 percent vanadium oxide (V_2O_5). Further details about Cotter's uranium and vanadium mining operations are described in the "Uranium" section, below.

Uranium

Uranium is a heavy, radioactive metal that is used mainly to generate electricity in nuclear power plants. Other uses for enriched uranium include powering nuclear-propelled military ships and submarines and as X-ray targets in making high-energy X-rays. Uranium is also used to manufacture plutonium in breeder reactors. Plutonium use is decreasing as fewer nuclear weapons are being manufactured by developed nations. Depleted uranium, the uranium that is left over after the most radioactive isotopes have been removed, is used in some helicopters and airplanes as wing counterbalances, as bullets or artillery shells, and as tank armor by some militaries.

Increased uranium demand for electric generation at nuclear power plants worldwide has tightened the supply and driven prices sharply higher over the past two years. In Colorado, several uranium mines opened in the last two years and several more are expected to begin operating soon. According to the U.S. Energy Information Agency (EIA), Colorado ranks third among the states for uranium reserves, behind Wyoming and New Mexico. In 2004, mines around the world produced about 106 million pounds of uranium oxide (U_3O_8) while consumption was 160 to 180 million pounds (Ux Consulting Company). Uranium derived from "downblending" highly enriched uranium from decommissioned Russian nuclear weapons made up most of the difference, but that source is predicted to run out by 2013. The average spot price for U_3O_8 was $18.55 per pound in 2004, which is the highest it has been since before 1987. Figure 44 shows average spot prices for U_3O_8 from 1987 through 2004. Term or contract prices are higher than spot prices, indicating that

further price increases are expected as demand continues to increase. In late 2003, the Chinese government announced plans to build 30 new nuclear power plants by 2020. The U.S. currently has 104 operating nuclear power plants, which produce approximately 20 percent of its electricity supply. Interest in additional nuclear power generation is being renewed as concern rises over global climate change and emissions of carbon dioxide from coal-, oil-, and gas-fired power plants. The 2003 study by MIT and Harvard scientists, *The Future of Nuclear Power*, is a comprehensive, interdiciplinary report on the future of nuclear energy that offers a number of recommendations for making nuclear energy an environmentally and economically viable option in the U.S.

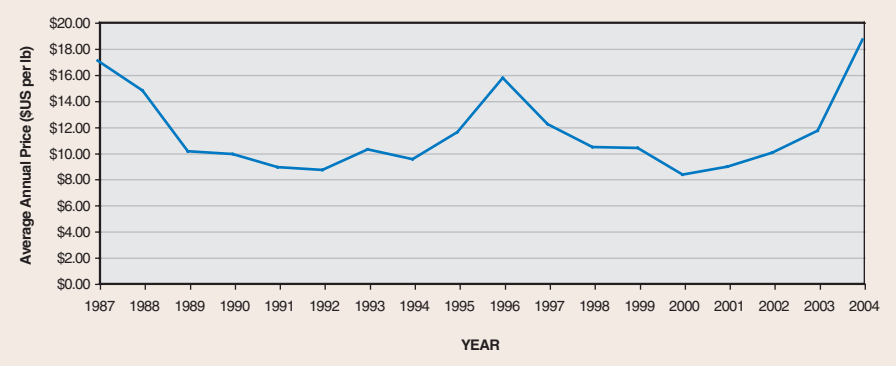

Figure 44. Average annual spot prices for uranium oxide (U_3O_8), 1987–2004. Data source: The Ux Consulting Company, LLC.

Cotter Corp. Mines, Montrose County: Englewood-based Cotter Corporation, a subsidiary of General Atomics Corp. of San Diego, California, opened three long-dormant uranium-vanadium mines near Nucla and Naturita in Montrose County in 2004. These are the JD-6, JD-8, and SM-18 mines. Cotter now operates four mines in all, including the JD-9, which opened in 2003. The company expects to open three more mines in 2005—the LP-21, JD-7, and SR-11. The mines employ 45 to 50 workers with more hiring expected as new mines open. In 2004, the mines produced 112,803 pounds of uranium from 15,210 ore tons mined. CGS estimates that the contained uranium has a value of $2.1 million based on the average 2004 uranium price. Cotter expects to achieve a production of 80,000 tons of ore in 2005 and 140,000 tons in 2006. Ore grades are expected to be 0.34 percent U_3O_8 and 1.84 percent vanadium oxide (V_2O_5). By the end of 2005, Cotter expects to be mining at a rate of 525 tons of ore per day. The uranium-vanadium ore is trucked from the mines to Cotter's mill in Cañon City where it is processed to yellowcake uranium concentrate and vanadium concentrate. The Cañon City mill employs about 75 workers. The yellowcake is sold to an enrichment plant in Illinois for further processing.

The Cotter Corp. mines are located in the famous Uravan mineral belt, the oldest uranium mining area in the U.S. and historically the most productive uranium and vanadium region in Colorado. The uranium and vanadium deposits are hosted in sandstone, primarily the Salt Wash Member of the Jurassic Morrison Formation. The Uravan mineral belt has around 1,200 historic mines that produced over 63 million pounds of uranium and 330 million pounds of vanadium from 1948 to 1978.

Base Metals

Colorado does not currently produce base metals (lead, zinc, and copper) but the state was a major producer of lead and zinc in the past and had moderate copper production, mainly as byproduct. All of these metals have numerous uses. About 80 percent of lead is used to make batteries. The main uses of zinc are anti-corrosion coatings on steel (galvanizing), and in precision metal components (die casting). Most copper is used to make electrical generators and motors, electrical transmission wire, and electronic goods.

The Leadville district in Lake County was by far the most prolific base metal district in the state. Mines in other areas produced base metals also, particularly in the Sawatch Range, the San Juan Mountains, and the central Front Range. One new copper mine in western Colorado, the Cashin, is currently being developed. With the prices of lead, zinc, and copper increasing steadily over the past two years (fig. 45), interest in exploring and developing other base metal deposits in Colorado may be renewed. The last mine to produce base metals in Colorado was the Black Cloud Mine in Leadville, which produced lead, zinc, silver and gold. The Black Cloud closed in 1999 after 30 years of production.

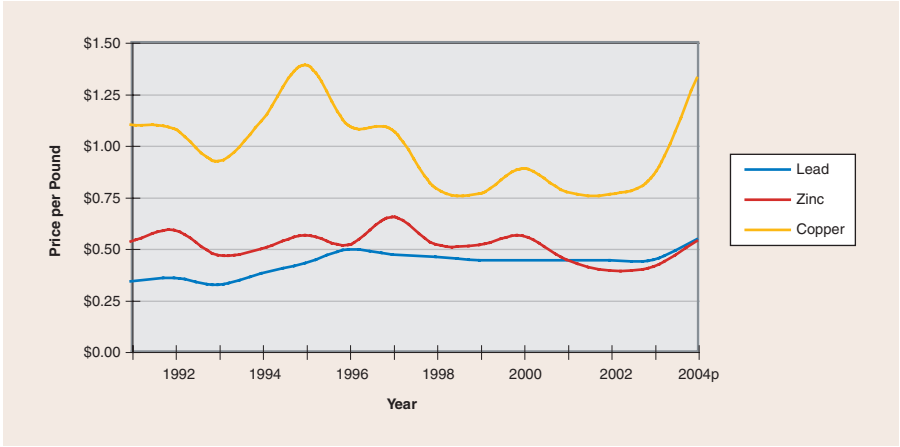

Figure 45. Average annual prices for lead, zinc, and copper, 1991 through 2004. Data compiled from U.S. Geological Survey Mineral Commodity Summaries, U.S. producer prices. (p = preliminary data)

Metal Exploration and Development Projects

Caribou District Project, Boulder County (gold, silver, and base metals): Calais Resources continued exploration and resource-definition drilling in the historic Caribou district near Nederland. The company drilled 8,900 feet of core in four deep holes. Specific targets of the drilling included the northeast-striking No Name vein system and the contact zone between the Caribou monzonite stock and Proterozoic gneiss. Drill holes successfully intersected mineralization in the No Name vein system. The Nelson veins were also intersected, and four previously undiscovered veins were also found below the footwall of the No Name vein. The new veins are below the northwest flank of Idaho Hill. One of the mineralized intercepts (0.539 ounce of gold per ton over 2.00 feet) was 1,975 vertical feet below the surface and is the deepest mineralization tested so far in the Caribou district. It is also one of the deepest intercepts in the entire Colorado mineral belt. Several other intercepts of 0.3 to 0.9 ounce of gold per ton were encountered as well, and these ranged from 2.5 feet to 6.0 feet in width (Calais Resources press release, July 1, 2004). Figure 46 shows core drilling at the project in 2004.

Total mineral resources at Calais' Caribou district properties currently stand at 437,240 ounces of gold and 12,575,240 ounces of silver, but this estimate is from August 2002 and does not take into account the most recent drilling data. Significant copper, lead, and zinc are present in the veins as well.

Figure 46. Angled core drilling on the No Name vein system, Caribou district, Boulder County. Drill is an Atlas Copco/Christensen QS 1000; photo courtesy of Tom Hendricks, Calais Resources Inc.

Figure 47. Core drilling hole 3CC-4 at a 30° angle *up* into cliff face of Wingate Sandstone at the Cashin copper deposit, Montrose County. Drill rig is a custom rig from Godbe Drilling LLC, Montrose, Colorado, modified to drill HQ-size up-holes specifically for this project; Photo by Jon Thorson; courtesy Constellation Copper, Inc.

Cashin Deposit, Montrose County (copper): The Cashin deposit is a sandstone-hosted copper deposit near the Colorado-Utah border that is currently being developed by Constellation Copper Corp. The mine will be a satellite operation to the Constellation's Lisbon Valley Mine, 15 miles to the southwest in San Juan County, Utah. The Lisbon Valley Mine and processing facilities are currently under construction. Pending further resource definition, mine engineering, and permitting, copper ore from Cashin will be trucked to Lisbon Valley for processing.

Constellation conducted additional drilling at Cashin in 2004 (fig. 47). New resource estimates indicate a resource of 10.5 million tons grading 0.525 percent copper. This yields over 110 million pounds of contained copper. Proven and probable mining reserves, calculated at the very conservative copper price of $0.95 per pound, are estimated at 5.25 million tons grading 0.52 percent copper with a waste:ore ratio of 0.74:1. As of mid-March 2005, copper traded at $1.45 to $1.50 per pound. Constellation expects that the Cashin deposit will add one year of production to the Lisbon Valley project. Copper was originally discovered in the Cashin area in 1896, and was mined from 1899 to the 1950s. Mineralization consists principally of malachite and azurite (fig. 48). Chalcocite, neoticite, and chrysocolla are also present. Native copper (and some native silver) was occasionally found in the high-grade parts of the historic mine. Copper mineralization at Cashin is hosted by the Wingate Sandstone of Triassic age.

Figure 48. Drill core with abundant malachite (blue-green color) and azurite (deep blue color) copper mineralization from a drill hole at the Cashin deposit, Montrose County. The core contained a 207-foot-long mineralized interval containing 0.654 percent copper. Photo by Jon Thorson; courtesy Constellation Copper, Inc.

Gold Hill district, Boulder County (gold, silver): A September 28, 2004 press release by Consolidated Global Minerals Ltd. of Vancouver, B.C. announced that it had purchased an underground drill, a surface exploration drilling rig, and mining equipment needed for the exploration of the Cash Mine and other areas in the Gold Hill district west of Boulder. They announced that several drill holes had been completed and one was in progress. Assay results from eleven rock chip samples taken from the 125 level workings at the Cash Mine averaged 1.59 ounces of gold per ton and 7.92 ounces of silver per ton. Additional sampling to check historical assays in underground workings is in progress. As of late March, 2005, 450 feet of a planned 500-foot crosscut on the third level of the Cash Mine had been completed. Work has also been done to retune the circuits at the 50 ton-per-day flotation mill, which was built in 1987. The mill operated briefly in 1988. The land position consists of 85 patented and 21 unpatented lode-mining claims, totaling 480 acres that includes the Cash, Rex, Who Do, St. Joe, and Black Cloud mines. Mines in the area produced gold and silver from narrow, but high-grade, quartz veins that cut Proterozoic gneiss and granitic rocks.

Bates-Hunter Mine, Gilpin County (gold): The Bates-Hunter Mine in Central City saw renewed development activity in late 2004. In September 2004, Wits Basin Precious Metals, Inc., a Minneapolis-based minerals exploration company, secured an option to purchase the Bates-Hunter Mine and the Golden Gilpin Mill. Central City Consolidated Mining Company is the present owner of the mine and mill, which has not produced ore since 1936 according to Wits Basin's company web site. The mine produced gold from ore shoots in steeply dipping fissure veins. Wits Basin recently announced plans to dewater and rehabilitate the shaft, to conduct exploration drilling from underground stations when the workings are rehabilitated, and to refurbish the Golden Gilpin Mill

Little Hope Mine, Teller County (gold): In 2004, Minerex Corp. applied for permits from the state and from Teller County for a proposed small, underground gold mine near Mineral Hill just north of the town of Cripple Creek. The mine, if developed, would produce gold ore which would be processed at a custom mill located elsewhere.

Little Maverick Mining Company, Whirlwind claim, Mesa County (uranium): In early 2005, the Little Maverick Mining Company submitted a mining plan to the U.S. Bureau of Land Management for a small-scale operation using an existing shaft at a site near Gateway in Mesa County. The site is on the Whirlwind claim near Lumsden Canyon. It was last mined about 20 years ago and is presently reclaimed. Fewer than 12 workers would be employed at the mine, which would produce about 500 tons of uranium ore per month.

Hansen deposit, Fremont County (uranium): The Hansen deposit in the Tallahassee Creek area of Fremont County is once again being examined for its uranium potential. In November 2004, Quincy Gold Corp. announced it had entered into letter of intent for an agreement with NZ Uranium LLC to explore the Hansen deposit. A resource of approximately 30 million pounds of uranium was outlined at Hansen in the late 1970s by Cyprus Mines Corp. Cyprus had designed an open pit mine and milling facility capable of processing 4,500 tons of ore per day and yielding 2 million pounds of uranium per year. It was projected to employ 550 people by 1983. The plan was abandoned, however, in 1980 when the price of uranium crashed due to decreased demand for nuclear fuel after the Three Mile Island incident. Quincy Gold is evaluating Hansen as a potential site for in situ solution mining.

Industrial Minerals and Construction Materials

The production of construction materials and many industrial minerals is largely tied to the health of the construction industry. In Colorado, the total number of housing permits (includes single and multi-family units) rose 15 percent from 39,569 in 2003 to 45,585 in 2004 (fig. 49)—a typical house requires approximately 400 tons of aggregate. Aggregate is a broad term and includes crushed stone, sand, and gravel (National Stone, Sand & Gravel Association [NSSGA]). Construction and

maintenance of highways and transportation corridors were also strong during the last year—one mile of highway requires an estimated 85,000 tons of aggregate (Minerals Information Institute [MII]). Production of many of Colorado's mineral resources rose accordingly to meet these demands. The largest segment of the non-fuel mineral industry in Colorado is aggregate—sand, gravel, and crushed stone.

Other important industrial minerals and construction materials currently being produced in Colorado include cement, clay, gypsum, dimension stone, silica sand, sodium bicarbonate, decorative stone, peat, and helium. Unless otherwise noted, most of the following information was obtained from the U.S. Geological Survey, directly from commodity producers, or from various news sources.

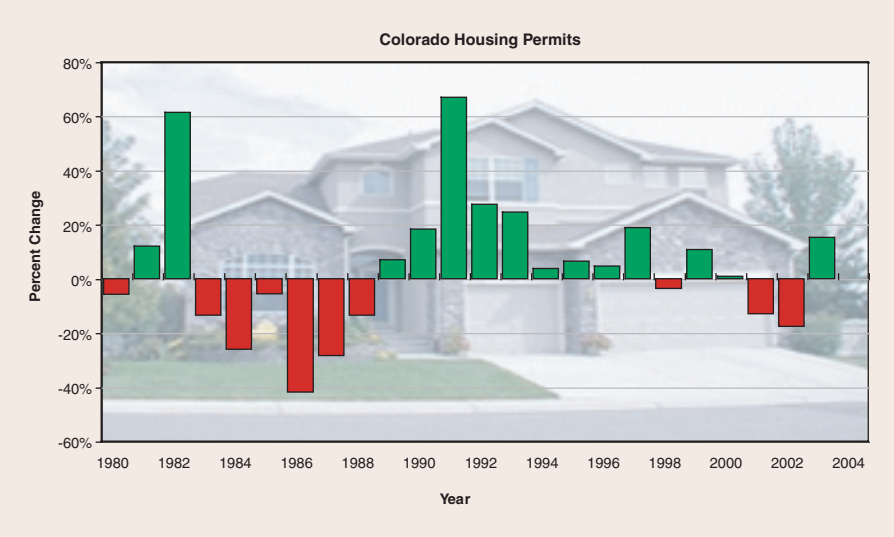

Figure 49. After three years of insignificant or negative growth in Colorado, new housing permits rose by 15 percent in 2004. Source: U.S. Department of Commerce. The average house in the U.S. requires 400 tons of sand, gravel, and crushed stone for its construction (NSSGA).

Aggregate—Construction Sand, Gravel, and Crushed Stone

Colorado produced nearly 57.1 million tons of aggregate in 2004 (fig. 50) and ranked seventh in the nation for sand and gravel production. The total value of Colorado aggregate was nearly $305 million, which is four percent more than the 2003 value of $292 million. Sand and gravel represented 80 percent of Colorado's total aggregate production in 2004. Sand and gravel production totaled 45.5 million tons—up 12 percent from last year's production. Crushed stone production increased by one percent over the revised figure for 2003 (10.4 million tons). Average unit values of $5.24 and $5.72 per ton were calculated for sand and gravel and crushed stone, respectively (fig. 51).

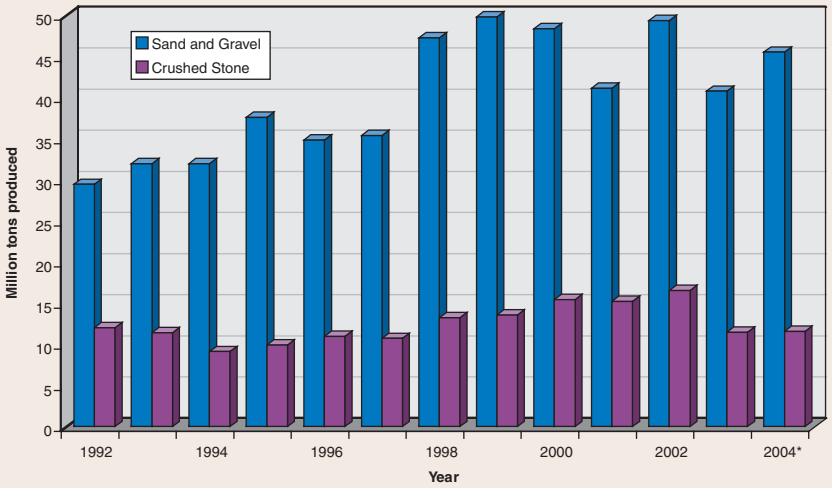

Figure 50. Production of sand and gravel vs. crushed stone in Colorado, 1992–2004.

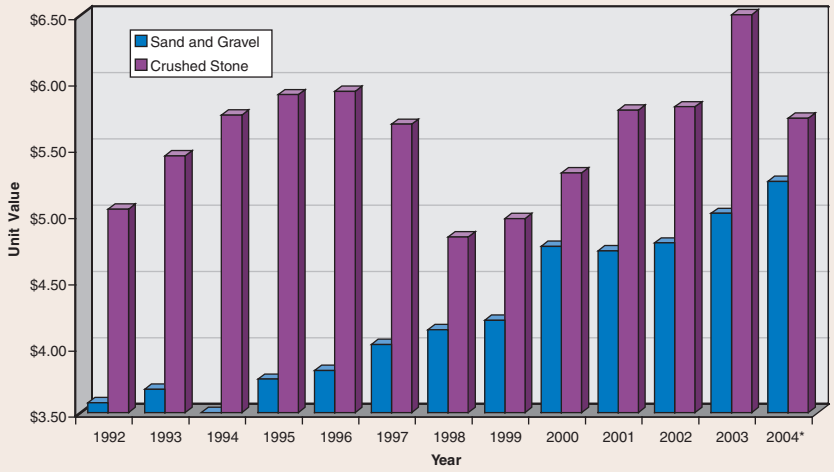

Figure 51. Average estimated unit value per ton of sand and gravel vs. crushed stone produced in Colorado, 1992–2004.

The top uses for sand and gravel are concrete aggregate, road base and coverings, construction fill, and asphaltic concrete aggregate. The national aggregate consumption trend is rising slightly due to a slowly growing economy and continued road and highway construction and repair. After a decline in 2003, demand

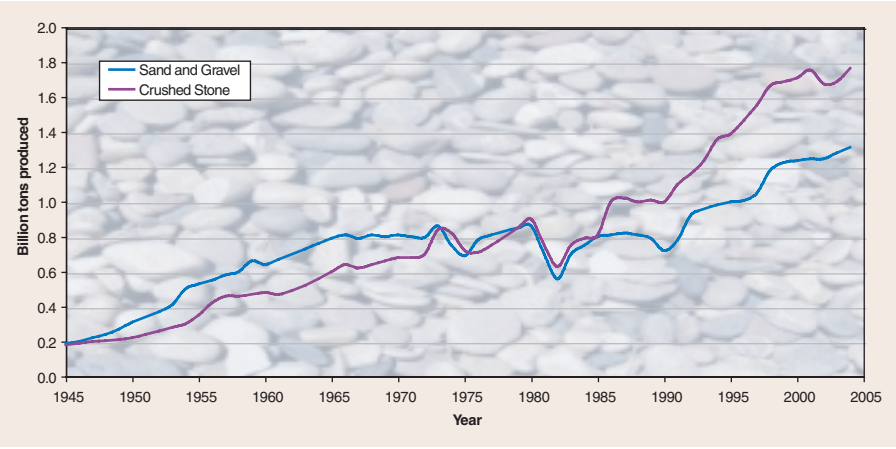

Figure 52. Production of sand and gravel vs. crushed stone in the U.S., 1945–2004 (estimated USGS figures for 2004). Crushed stone surpassed sand and gravel as the dominant aggregate type in the 1980s. However, Colorado deviates from the national trend and produces more sand and gravel than crushed stone.

for sand and gravel in Colorado increased by 2.3 percent in 2004. A rising trend is expected as our economy strengthens and construction continues on the Interstate 25 transportation project (T-Rex) and other major roadways in the state.

Although the use of sand and gravel predominates in Colorado, the use of crushed stone as an alternative to sand and gravel nationally is gaining momentum (fig. 52). Crushed stone quarries typically operate within a smaller footprint and can be located further from high-density urban areas and scenic and environmentally contentious river valleys, so are preferred over sand and gravel operations. Although higher operating costs equate to higher prices for crushed aggregate, the cost differential is slowly decreasing due to escalating conflict over environmental and land use issues associated with sand and gravel operations.

Trends in Aggregate Mining

The national trend in aggregate production is towards "super quarries"—quarries that mine massive volumes of sand, gravel, or crushed stone and ship the material to redistribution centers, or sales yards, across the country and even globally. This trend is spurred by the continuing conflict between resource extraction and zoning, environmental policy, and land development. While opposition to expansion of existing operations is relatively low, obtaining permits for new quarries commonly requires an often prohibitive amount of time and money.

Several counties in Colorado are not able to meet their aggregate needs independently and must import aggregate from nearby counties with excess production. For many counties in eastern and southwest-central Colorado, this deficit is strictly geologic, meaning there simply are not enough deposits from which to extract aggregate of sufficient quality. However, for a growing number of counties this deficit is socioeconomic and has more to do with "sterilization" of deposits through preemptive zoning, development, and community opposition. Limitations on resource availability translate to increased costs. Counties that must purchase aggregate from a distribution center or sales yard will pay an average of $2.70 per ton in additional costs.

Although advances in mining technology help to offset the increased costs to consumers, the overall outlook is towards rising aggregate costs, particularly in urban and industrialized areas. Counties must strive for long-term resource management and early planning for the efficient use of aggregate resources.

Industrial Sand and Gravel

In 2004, about 77,161 tons of industrial sand and gravel were produced in the state, which is roughly the same amount produced in 2003. Monetary value of this commodity is about $3.0 million in 2004. Colorado's leading industrial sand company is the Ohio-based Oglebay Norton Company. The local division office, Oglebay Norton Industrial Sands, is located in Colorado Springs and supports 25 to 30 employees. The company markets "Colorado Silica Sand," specialty industrial sand that is used primarily as filter media for water purification plants and as a construction material largely for stucco. Some of their smaller markets include hydraulic fracturing material for oil and gas drilling mud, gravel packs around water wells, and other applications where roundness, permeability, and strength are important parameters. Additionally, the sand is used as a landscaping material. The majority of product is exported outside of Colorado. Currently, Oglebay Norton extracts (essentially recycles) its silica sand from waste material cut from new developments where much of the surface cover is removed or scraped off before construction begins. The surface materials are generally Quaternary-age eolian deposits consisting mostly of well-sorted and well-rounded grains of quartz. The company is actively exploring for other silica sand resources in Colorado.

Dimension Stone

Dimension stones are quarried slabs or blocks of attractive rock that are used for decorative construction, facing panels, flagstone, sculptures and monuments, and many other projects requiring large, competent masses of stone. Many dimension stone producers may also crush and market some of their stone for landscaping purposes. Colorado produced 5,777 tons of dimension stone in 2004 with an estimated value of $1.5 million. This is a 13 percent increase over 2003 production. The principal Colorado dimension stones include marble, sandstone, granite, and rhyolite. Improvements in quarry techniques and rising costs of some other construction materials have lead to renewed interest in the use of stone as a building material, particularly in residential markets.

Colorado Quarries Inc., Custer, Chaffee, Fremont, Teller Counties: Colorado Quarries operates several quarry operations in the Front Range area that produce dimension stone, decorative stone, and crushed stone. In 2004, they produced approximately 33,000 tons of stone and employed 14 people. Marketed products include White Quartzite from Howard; Ruby Spar, RG Rose Quartz, and Flamingo Quartz from near Canon City; Green and Indian Rhyolite and Black Obsidian from near Westcliffe; Red Granite from near Guffey; and Gray Granite from near Texas Creek. These materials are used principally in the landscape industry as decorative boulders, building stone, and crushed stone. Their materials are also used in the pre-cast market (panels on buildings and other structures). Standard stone mining equipment is used at all quarries. Stone from Colorado Quarries Inc. has been used on the Pepsi Center, the Colorado Convention Center, the Colorado Springs Airport and U.S. Air Force Academy.

Arkins Park Stone, Larimer County: Arkins Park Stone Corporation employs about 40 people and operates three quarries near the town of Masonville. Production for 2004 was about 8,174 tons. The company produces buff sandstone as well as "Berthoud Pink" and "Berthoud Sunset" sandstone from the Permian Lyons Sandstone. Approximately 80 percent of the product is sold or used in Colorado. Much of the stone is used as flagstone and facing in the construction of buildings. Recently, the company also began producing rip-rap for commercial uses such as riverbed linings, dams, and bridge abutments.

Yule Quarry, Gunnison County: In April 2004, Sierra Minerals sold the Yule Quarry to Colorado Stone Quarries (CSQ), a subsidiary of Polycor, Inc. of Quebec, Canada. Polycor operates marble and granite quarries in North America, has a number of fabricating facilities, and has a substantial presence in international stone markets. CSQ brought in an experienced operating manager and more modern quarrying equipment, which resulted in significantly expanded production in the latter portion of 2004 and into 2005. Downtime during the sale of the quarry, however, resulted in a net production of 1,870 tons—down 11 percent from 2003. Production in 2005 should show significant increase. During 2004, the quarry averaged about 10 employees working on site. The bulk of the quarried stone is used for sculpting, national cemetery headstones, and monuments, although recently, slab and tile stone production has been on the rise. Structures utilizing the Yule Marble include the Tomb of the Unknowns and Lincoln Memorial in Washington, D.C., the Colorado State Capitol and Annex buildings, Denver International Airport, and more than 100 other buildings across the nation. The Yule Marble is Colorado's official State Rock.

Other Colorado Dimension Stone: The Colorado Red Rose Quarry in Larimer County produces blocks of red granite for use as countertops and monuments. Alabaster is quarried from the Permian Lykins Formation at a small mine near Fort Collins by Colorado Alabaster Supply. Their alabaster is used mainly for sculpting and is marketed both locally and nationwide. The White Banks Mine in Pitkin County produces alabaster, as well as dark-colored marble and quartz. The Eocene-age Wall Mountain Tuff, known in industry as Castle Rock rhyolite, is quarried by the Ames Construction Company near the town of Castle Rock. Numerous other small operations quarry various sandstone units throughout the state.

Decorative Stone

Decorative stone has become a more important part of the Colorado minerals industry in recent years. Both crushed rock and whole boulders are used. Granite, gneiss, sandstone, volcanic rock, obsidian, marble, and quartz pegmatite are some of the rock types currently being mined in the state for decorative use. Natural boulders that have a covering of lichen on them are commonly known as "moss rock" in the landscaping industry. Usually, the larger the percentage of the rock covered with the colorful lichen, the more valuable it is. Numerous small decorative stone mines and quarries are located in Colorado. No specific production figures are available for statewide decorative stone production.

Clay and Shale

The majority of the clay mined in Colorado is common clay, which is used mainly to make bricks and tiles or in the manufacture of cement and lightweight aggregate. Common clay is mined primarily in eastern Colorado, especially near the Front Range in Jefferson, Elbert, Douglas, El Paso, Pueblo, and Fremont counties. In 2004, Colorado clay mines produced 288,695 tons of clay, which represents an increase of about one percent over 2003 (fig. 53). The value of this clay was estimated at just over $1.4 million. In eastern Colorado, clay is mined principally from three formations: the Laramie Formation (Upper Cretaceous), the Dakota Sandstone (Lower Cretaceous), and the Dawson Formation (Upper Cretaceous to Tertiary). Elsewhere in the state, clay deposits within the Lykins, Morrison, Benton, Niobrara, Mesaverde and Vermejo Formations (ranging in age from Triassic to Cretaceous) have also been exploited.

Higher quality clays have also been produced from the Dakota and Dawson Formations. Both are local sources for refractory clay, which is used in the manufacture of refractory ware, such as crucibles and high temperature firebricks for kilns. Current market demands have not warranted active mining of these deposits. Additionally, bentonite clay layers are found in altered volcanic ash in Fremont County, and locally in the Jurassic Morrison Formation and the Cretaceous Pierre Shale. Bentonite is frequently used as an absorbent (such as in kitty litter or spills involving hazardous fluids) and as a containment barrier (such as in clay liners for landfills). However, there was no bentonite production reported in Colorado in 2004. The principal producers of clay products are located in the Front Range area and include Denver Brick Co., Robinson Brick Co., Summit Brick and Tile, Co., and TXI Operations.

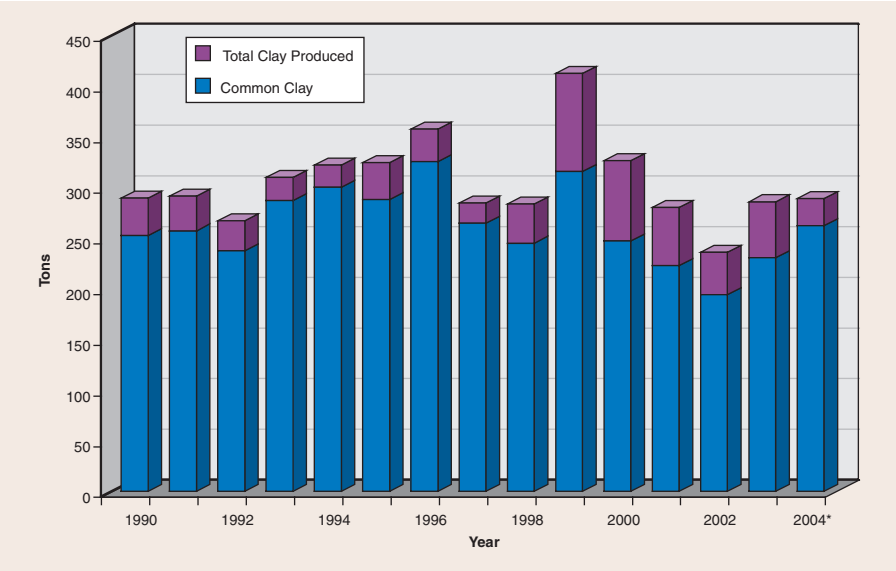

Figure 53. Total clay production in Colorado increased by about one percent from 2003 to 2004. Most of the clay mined in Colorado is common clay, which is used primarily for making bricks. Clay not used in the manufacture of bricks may include bentonite, fire clay, and clay used in other construction applications.

Summit Brick and Tile Co., El Paso, Fremont, and Pueblo Counties: In 2004, roughly 62,400 tons of clay were produced from ten Summit Brick-owned mines. This represents a 6.4 percent decrease compared to 2003. Approximately 27 million bricks are manufactured annually at the plant, about 40 percent of which are shipped within Colorado and the remainder of which are shipped throughout the U.S. Raw clay costs average about $10 per ton delivered to the plant yard. The average price for face brick is about $325 per 1000 units.

Summit's mines and plant employ approximately 85 people. One of the Summit mines produces common clay for brick manufacturing from the Cretaceous Pierre Shale. Three other mines produce fireclays from the Cretaceous Dakota Group, which are used to manufacture white brick. Summit's red-burning clays are derived from the Morrison Formation and from the contact zone between Precambrian Pikes Peak Granite and the Pennsylvanian Fountain Formation. Standard open-pit mining techniques are used at all the mines. This involves removal and stockpiling of overburden material, excavation of the clay deposit, and then back filling to reclaim the area. Summit Brick has participated in the Occupational Safety and Health Administration Safety and Health Achievement Recognition Program since 2001, and has received a Certificate of Recognition from Colorado State University and the U.S. Department of Labor.

TXI Operations, Jefferson County: The Pierre Shale in northern Jefferson County is mined by TXI for use as lightweight aggregate. The mined shale is kiln-fired to the point where it expands in size and becomes low in density and weight. Lightweight aggregate is used in place of regular sand, gravel, or crushed stone in applications where excessive weight is undesirable, such as floors and walls in multi-story buildings. Cinder blocks are commonly made with lightweight aggregate.

Gypsum

Most gypsum production goes towards the manufacture of wallboard and plaster products. Gypsum is also used as a cement ingredient, as a soil conditioner, and in other industrial uses such as glassmaking and smelting. As with sand, gravel, and crushed stone, the gypsum market follows trends in the construction industry. Growth in Colorado's residential construction sector has spurred a slight increase in local gypsum production. The principal producer of gypsum in Colorado is *American Gypsum. Colorado Lien* and a few other small operations produce gypsum as a cement ingredient.

American Gypsum, Eagle County: The American Gypsum Mine and wallboard plant, located near the town of Gypsum, produced 620,000 tons of gypsum in 2004. This represents about a five percent increase in production over 2003. Approximately 600 million square feet of wallboard are manufactured annually at the plant. About 50 percent of the wallboard goes to the Colorado construction industry, and the remainder is marketed throughout the U.S. The gypsum is excavated from evaporite deposits in the Pennsylvanian Eagle Valley Formation using a pavement grinder. The company is in the process of developing a new mining area northeast of the current site. Over a span of a few years, mining will shift to the new site as reserves are depleted in the original site. The future mining area ensures that the wallboard plant can operate for at least another 20 years. The mine and plant employ approximately 120 people.

Colorado Lien, Larimer County: Colorado Lien, subsidiary of Pete Lien & Sons, Inc. of South Dakota, produces gypsum from the Munroe Quarry north of Fort Collins near Livermore. Gypsum is extracted from the Permian Lykins Formation using a portable crusher. Annual production averages about 25,000 tons. The majority of the material quarried is sold within the state to the cement industry.

Cement

Cement is a manufactured product consisting primarily of lime (which is derived from limestone) and shale. Other ingredients may include gypsum and silica sand. The main cement manufacturers in Colorado are Holcim (US) Inc. and CEMEX, Inc. The two companies produced a combined 2.6 million tons of cement in 2004. This is an increase of more than 50 percent compared to the 1.7 million metric tons produced in 2003. The increase is largely due to Holcim ramping up production to plant capacity, which increased their production by nearly one million

tons. Nationwide cement prices rose as much as 20 percent in 2004 because of shortages in supply caused by continued growth in the construction (particularly residential) industry (RBI). Demand for cement is expected to remain strong despite a predicted leveling out in the residential construction sector (PCA).

Holcim (US), Inc., Fremont County: The Portland Plant near Florence is operated by Holcim (US), Inc. In 2004, the plant employed about 180 people and operated at capacity to produce 2.1 million tons of cement. The majority of their product is used in the metropolitan Denver area and throughout Colorado; some cement is also distributed to western Kansas and Nebraska. Limestone from the Fort Hays Member of the Niobrara Formation of Upper Cretaceous age is mined by Holcim as the principle raw ingredient for their cement. The Codell Sandstone, also Cretaceous, is mined for use as a silica additive. Most of the company's gypsum is imported from Oklahoma, although they have also been looking into local resources. An older, defunct Holcim-owned cement plant near La Porte was fully demolished in 2004. Reclamation of the site will continue through 2006 and 2007. In other news, parent company Holcim Ltd. received valid acceptance in January 2005 of their offer to purchase U.K.-based Aggregate Industries. Regulatory authorities in the U.K have approved the deal and the takeover appears to be moving forward as of late March 2005.

CEMEX, Inc., Boulder County: Portland and masonry cement are produced at the CEMEX, Inc. mine and processing plant near Lyons. The plant uses the dry processing method and employs about 100 people. Cement production in 2004 was 507,000 tons, most of which was utilized in the greater metropolitan Denver area. Cement ingredients (limestone and shale) are mined locally from the Niobrara Formation and the overlying Pierre Shale.

GCC Rio Grande, Inc., Pueblo County: GCC Rio Grande, Inc., a subsidiary of Grupo Cementos de Chihuahua, has been planning and permitting a new cement plant in Pueblo during the past several years. The proposed mine and processing plant is expected to produce about one million tons of cement per year and will employ nearly 100 workers. The Fort Hays Member of the Niobrara Formation will be mined as the main cement ingredient. Gypsum, another ingredient of cement, will be mined locally as well. Construction of the facility is scheduled to begin in mid-2005.

Soda Ash and Sodium Bicarbonate

Natural Soda AALA, Inc., Rio Blanco County: Natural Soda, Inc. produces sodium bicarbonate (baking soda) derived from nahcolite that is solution mined in the Piceance Basin in northwestern Colorado. In 2004, the plant produced 79,375 tons of sodium bicarbonate. This compares to 77,513 tons in 2003. Prices for sodium bicarbonate remained stable in 2004.

High-grade nahcolite (>80 percent) is recovered from the "Boise Bed" of the Green River Formation by injecting hot water that dissolves the nahcolite, and then pumping the saturated water back to the surface. Dissolution of the nahcolite is through horizontal drill holes along the base of the Boise Bed. Natural Soda's mine has a designed capacity of 125,000 tons per year. Both food-grade and industrial-grade products are marketed. Natural Soda also owns the Rock School Lease, an undeveloped nahcolite property nearby. The two properties, both leased from the U.S. Department of the Interior Bureau of Land Management, together comprise over 9,500 acres in the Piceance Creek Basin. These leases contain in situ nahcolite resources estimated to exceed 4 billion tons.

American Soda LLP, Rio Blanco County: American Soda, owned by Solvay Chemicals, Inc., mothballed its large nahcolite solution mine in the Piceance Basin northwest of Parachute in spring 2004, laying off approximately 50 people. The processing plant had manufactured soda ash and sodium bicarbonate from the nahcolite. The plant still produces sodium bicarbonate using trona brought by rail to Parachute from Solvay's trona mine in Green River, Wyoming. The mine and plant had a potential production capacity of 800,000 tons per year of soda ash and 150,000 tons per year of sodium bicarbonate. The company controls over 7,000 acres of mineral leases on Bureau of Land Management land.

Peat

Peat is a mixture of decomposed organic matter, the quality of which is determined by the level of decay. Sphagnum moss is the least decomposed and highest quality. Hypnum moss, reed-sedge, and humus are progressively more decomposed and of decreasing quality. Peat promotes plant growth and has widespread use as a soil additive in the agricultural and horticultural industries. It can also be used to filter or absorb contaminated water or hazardous material spills. There are four permitted peat mines in Colorado, although only one of the mines is currently producing. This small, intermittent operation near Alamosa produces humus-grade peat to fill local landscaping needs. The peat is extracted from a dry bog as opposed to wetland areas typical of other worldwide peat resources. Colorado demand for peat is met primarily through imports, mostly from Canada.

Gem and Specimen Minerals

According to preliminary USGS estimates, the total reported value of 2004 gemstone production in Colorado was $359,000. This is an increase of 31 percent compared to the estimated 2003 value of $274,000.

Rhodochrosite

The Sweet Home Mine near Alma in Park County closed on October 18, 2004, ending 40 years of production of the world's finest rhodochrosite specimens. The mine was closed because of the ever-increasing difficulty of locating new pockets. Bryan Lees, owner of the mine, lamented to the *Denver Post* "it's the end of an era. It's finished." Paul Bartos, director of the Geology Museum at the Colo-

rado School of Mines told the *Post* "it's a sad day to see the Sweet Home close. Overall, the aesthetics of the Sweet Home can't be better. This is nature's art." The Sweet Home began as a marginal silver mine in 1873. The high value of the brilliant and well-formed cherry red rhodochrosite crystals in the mine was not realized until almost 100 years later. In 2002, Governor Owens signed a bill that made rhodochrosite the Colorado State Mineral.

Amazonite

Amazonite and smoky quartz are specimen minerals found in pegmatites within Pikes Peak Granite near Florissant and Lake George west of Colorado Springs. Amazonite is a bright blue-green to bright-green variety of microcline feldspar. The crystals found in the Pikes Peak region rank as some of the best in the world. Independent prospectors and miners work small mines in the pegmatites to find pockets containing the beautiful crystals, which are sold at gem and mineral shows, in rock shops, and on the internet.

Smoky quartz

A U.S.-record smoky quartz crystal was discovered in Teller County, Colorado in 2004. The crystal was discovered and excavated by Richard Fetterd on The Godsend Claim near Crystal Creek. The crystal weighs 439 pounds and is four feet long. An even longer crystal, 4 feet 3 inches long, but weighing less at 345 pounds, was also discovered nearby. Smoky quartz occurs in pegmatite cavities in Precambrian Pikes Peak Granite and is sometimes associated with amazonite specimens. Smoky quartz also occurs in pegmatite cavities in Tertiary-age granite on Mount Antero. Gem-quality aquamarine specimens were also found there.

Aquamarine

Aquamarine, a form of beryl, is Colorado's official State Gemstone. Gem-quality light blue crystals are found in Colorado just below the summit of the 14,000-foot-high Mount Antero in the Sawatch Range in Chaffee County. Aquamarine crystals are found in large miarolitic cavities within pegmatites associated with Tertiary-age granite stocks. The Mount Antero locality is considered one of the finest in North America for collecting this prized mineral, and specimens are displayed in many museums. Although there is no commercial mining of the stone in Colorado, many mineral collectors visit the Mount Antero site every summer. In 2004, the *Mountain Mail* reported that Rick Tekancik, Brandon Henderson, and Stuart Gehrke, all of Salida, discovered a major pocket that contained smoky quartz crystals and plates. Some of the plates weighed more than 500 pounds. The pocket is reportedly the largest ever documented on Mount Antero, and measures 20 feet long and 14 feet wide. Although no aquamarines had been discovered with the smoky quartz at the time of the *Mountain Mail* article, the three partners were optimistic that aquamarines would be found as the cavity was excavated further.

Turquoise

A small turquoise mine is operated on Mineral Hill north of Cripple Creek's casino district by the Bad Boys of Cripple Creek Mining Company, Inc. The "mom and pop" company run by David and Harriet Graham has worked the deposit for several years. The company also makes and sells jewelry with the turquoise. About 220 pounds of turquoise are recovered annually. Other turquoise deposits in the state include the King Mine in Conejos County, the Turquoise Chief Mine in Lake County, and the Hall Mine near Villa Grove in Saguache County. These mines are not currently active.

Helium

Grade-A helium is produced at the Ladder Creek natural gas processing plant near Cheyenne Wells in southeastern Colorado. The helium is liquefied at minus 458° F to separate it from the natural gas produced in the process. Helium is used for many purposes including medical imaging, welding, pressurizing and purging rockets, scientific and party balloons, fiber-optic cable production, production of metal alloys, and many others. The Ladder Creek plant produces approximately 120 million cubic feet of Grade-A helium per year and has 12 employees, according to a June 6, 2004, article in the *Denver Post*. Helium prices range from about 6 to 7 cents per cubic foot. The USGS estimates that the total U.S. private production of Grade-A helium extracted from natural gas in 2004 was 3.0 billion cubic feet, a slight decline from 2003. Kansas, Texas, New Mexico, Oklahoma, Utah, and Wyoming also produce helium from natural gas.

INFORMATION SOURCES AND ACKNOWLEDGEMENTS

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Baker Hughes Inc., **http://www.bakerhughes.com/investor/rig/**

Calais Resources Inc., **http://www.calaisresources.com/colorado.html**

CDMG, Colorado Division of Minerals and Geology, **http://mining.state.co.us/**

Climax Molybdenum Company, **http://www.climaxmolybdenum.com/**

CMA, Colorado Mining Association, **http://www.coloradomining.org/**

Coal Age magazine, **http://www.mining-media.com/ca/index.html**

COGCC, Colorado Oil and Gas Conservation Commission, **http://oil-gas.state.co.us/**

Colorado Business Economic Outlook Forum, University of Colorado at Boulder, **http://leeds.colorado.edu/brd/interior.aspx?id=254,289,290,630,631**

Colorado Department of Labor and Employment, **http://www.coworkforce.com/**

Colorado Department of Local Affairs, **http://www.dola.state.co.us/LGS/FA/EMIA/miner/Index.htm**

Consolidated Global Minerals Ltd, **http://www.cgmltd.com/news/index.php**

Constellation Copper Corporation, **http://www.constellationcopper.com/press.php**

Cotter Corporation, **http://www.cotterusa.com/**

Cripple Creek & Victor Mining Co., Anglo Gold Ashanti Ltd., **http://www.anglogold.com/subwebs/informationforinvestors/AnnualReport04/report/default.htm**

Denver Post, numerous articles, **http://www.denverpost.com/**

EIA, U.S. Department of Energy, Energy Information Administration (natural gas), **http://www.eia.doe.gov/oil_gas/natural_gas/info_glance/natural_gas.html**

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IMAO, International Molybdenum Association, **http://www.imoa.info/**

Jarrell, P. M., Fox, C. E., Stein, M. H., and Webb, S. L., 2002, *Practical Aspects of CO_2 Flooding,* Society of Petroleum Engineers Monograph v. 22.

Kitco, Inc., **http://www.kitco.com/scripts/hist_charts/yearly_graphs.cgi**

LKA International Inc., **http://www.lkaintl.com**

Metals Economics Group, reports on exploration trends to the PDAC conventions, **http://www.metalseconomics.com/frame_exploration_reports.html**

MII, Minerals Information Institute, **http://www.mii.org/**

The Mining Record, **http://www.miningrecord.com/**

Moritis, G., 1998, EOR Oil Production Up Slightly, *Oil & Gas Journal,* v. 96, no. 16.

The Mountain Mail, Salida, Colorado, **http://www.themountainmail.com/**

MSHA, Mine Safety and Health Administration, U.S. Department of Labor, **http://www.msha.gov/**

Natural Soda Inc., **http://www.naturalsoda.com/main.aspx**

NSSGA, National Stone, Sand & Gravel Association, **http://www.nssga.org/**

Paydirt magazine.

PCA, Portland Cement Association, **http://www.cement.org/exec/01-21-05.htm#1**

Phelps Dodge Corporation., **http://www.phelpsdodge.com/**

Quincy Gold Corporation, Hansen uranium deposit information, **http://www.quincygold.com/htdocs/hansen.html**

RBI, Reed Business Information, **http://www.purchasing.com/article/CA446771.html?text=cement**

Rocky Mountain News, numerous articles, **http://www.insidedenver.com/**

USGS, U.S. Geological Survey, Minerals Information Team, **http://minerals.usgs.gov/minerals/**

The Ux Consulting Company, LLC, **http://www.uxc.com/**

Wits Basin Precious Metals Inc., **http://www.witsbasin.com/**