Information Series 69

COLORADO
DEPARTMENT OF
NATURAL
RESOURCES

Colorado Mineral and Mineral Fuel Activity

2003

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COLORADO
DIVISION OF
MINERALS
&
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Division of Minerals and Geology
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COLORADO
GEOLOGICAL SURVEY

Cover: clockwise from left—Drilling activities in the Piceance Basin, photo by Colorado Oil and Gas Conservation Commission; Xcel Energy's Cameo Power Station, near Palisade, Colorado; Exploration core drilling into a vertical cliff of Wingate Sandstone at the Cashin copper deposit, Montrose County, December 2003

CONTENTS

FOREWORD

The Department of Natural Resources is pleased to present the Colorado Geological Survey Information Series 69, *Colorado Mineral and Mineral Fuel Activity, 2003.* Its purpose is to describe exploration, development, and production activity of the gas and oil, coal, and mineral industries of the state in 2003. The report also includes information on the economic impact of these industries to the state.

The legislature mandated that, "the Colorado Geological Survey shall prepare an annual report describing the status of the mineral industry and describing current influences affecting the growth and viability of the mineral industry in the state, and setting forth recommendations to foster the industry."

The staff of the Mineral and Mineral Fuel Resources Section of the Colorado Geological Survey gathers this information through the year and prepares the report every March. The objective of this publication is to provide geological information to resource developers, government planners, and interested citizens.

This project is funded through the Colorado Department of Natural Resources Severance Tax Operational Account. Severance taxes are derived from the production of gas, oil, coal, and minerals.

We hope this report provides useful information to Colorado's scientific, business, academic, and government communities.

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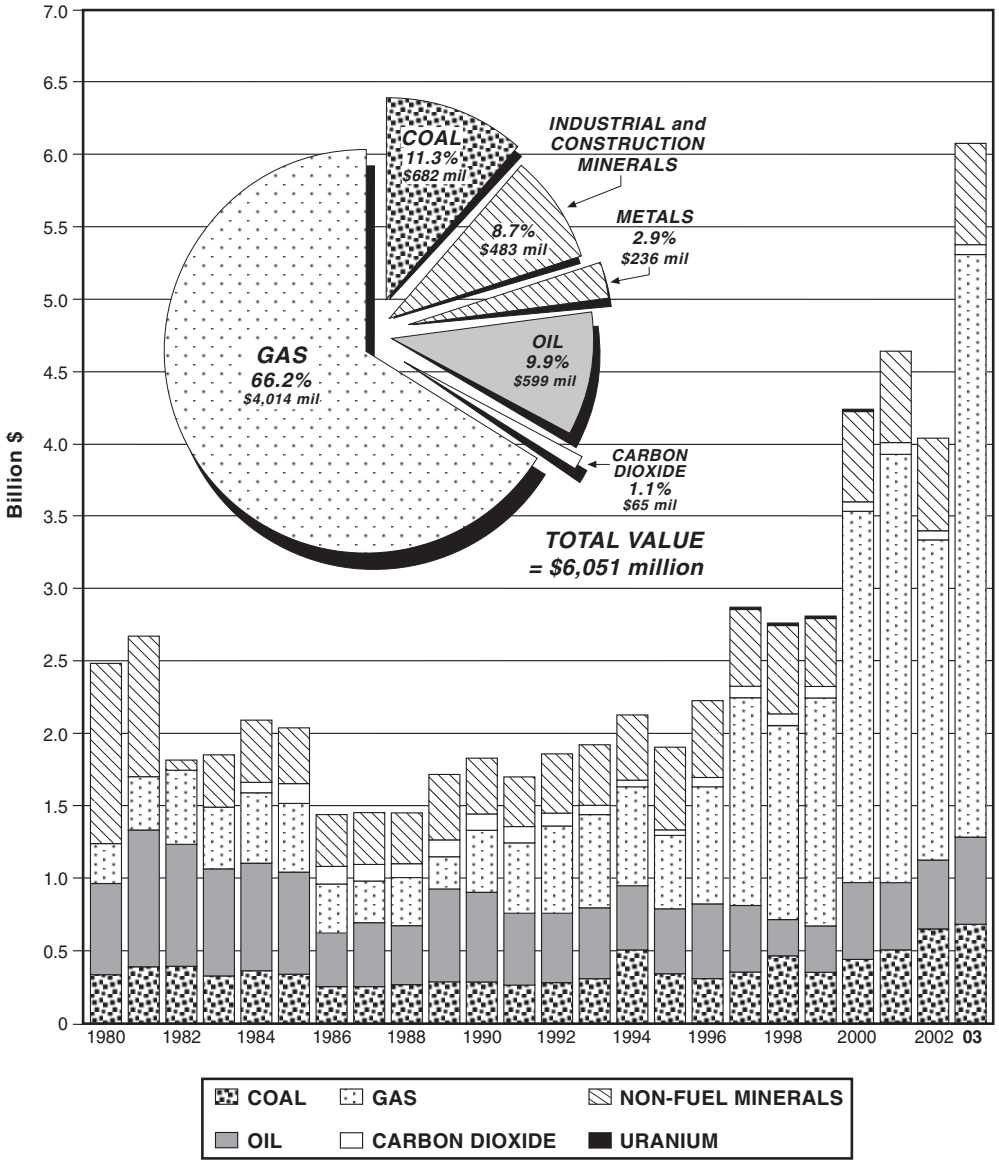


Figure 1. Value of Colorado mineral and mineral fuel production, 1980–2002.

By James Cappa

The Colorado Geological Survey (CGS) Mineral and Mineral Fuel Resources Section estimates the total value of 2003 mineral and mineral fuel production in Colorado to be $6,051 million, a 49 percent increase from the (revised*) 2002 total value of $ 4,061 million (Fig. 1).

Mineral fuel, carbon dioxide, and non-fuel mineral production values for 2003 are estimated at:

- Oil—$598.7 million
- Natural gas—$4,013.9 million
- Carbon dioxide (CO_2)—$64.47 million
- Coal—$682 million
- Non-fuel minerals—$702 million

The total estimated value of oil, natural gas, and carbon dioxide production in 2003 was $4,667 million, which is up 70 percent from the 2002 value of $2,743 million. Colorado natural gas and oil production both increased. Prices for gas and oil climbed strongly during 2003. The value of carbon dioxide production increased slightly from $62 million to $64.5 million.

Coal production increased from the 2002 level of 35.2 million tons to a record 35.9 million tons in 2003. Coal prices, which vary from mine to mine, are estimated at an average $19

** The 2002 production values for all commodities are revised from the* Colorado Geological Survey Mineral and Mineral and Fuel Activity report for 2002.

This report is written in March of 2004. Oil and gas and non-fuel mineral production values included in this report are always estimates for the preceding year. Final production values for 2003 will be available by the end of the 2004.

per ton for 2003. The value of Colorado coal production is estimated at $682 million, up 11 percent from the 2002 value of $616 million.

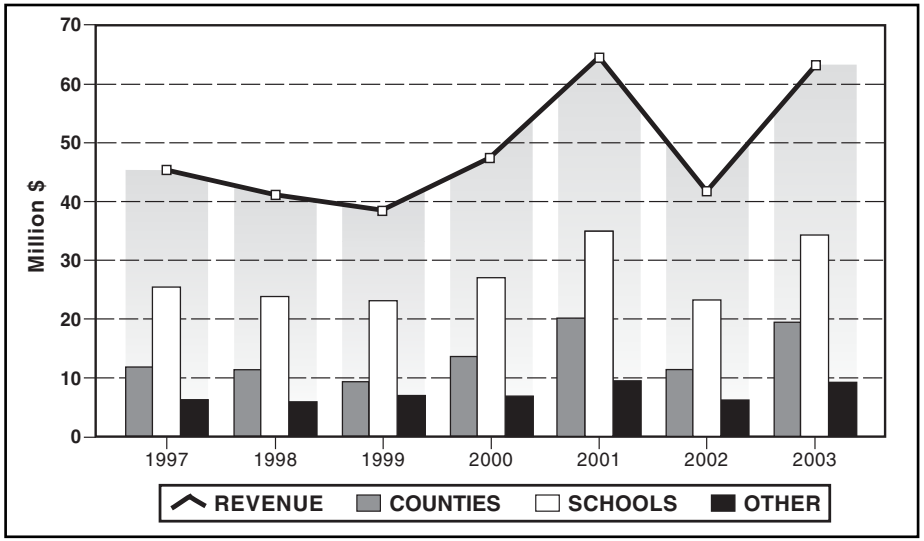
The CGS and the U.S. Geological Survey Mineral Information Office estimate the value of the 2003 non-fuel mineral production to be $702 million, an 11.6 percent increase from the 2002 value of $629 million. Price increases for both molybdenum and gold were a factor in the increase of non-fuel mineral value.

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 2003 is $63.1 million, a 51 percent increase from the 2002 value of $41.8 million. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (Fig. 2a. 2b).

Severance taxes on mineral and mineral fuel production also provide revenue to state and local governments. 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 year 2003 were $32.3 million, down 43 percent from the 2002 severance tax collection of $57.1 million (Fig. 3).

Estimated property taxes paid in 2003 to the counties from mineral and mineral fuel properties totaled $153 million (Fig. 4). All Colorado counties except Denver County receive revenue from mineral related property taxes.

Figure 2a. Federal mineral lease revenue and distribution in Colorado, 1988—2003.



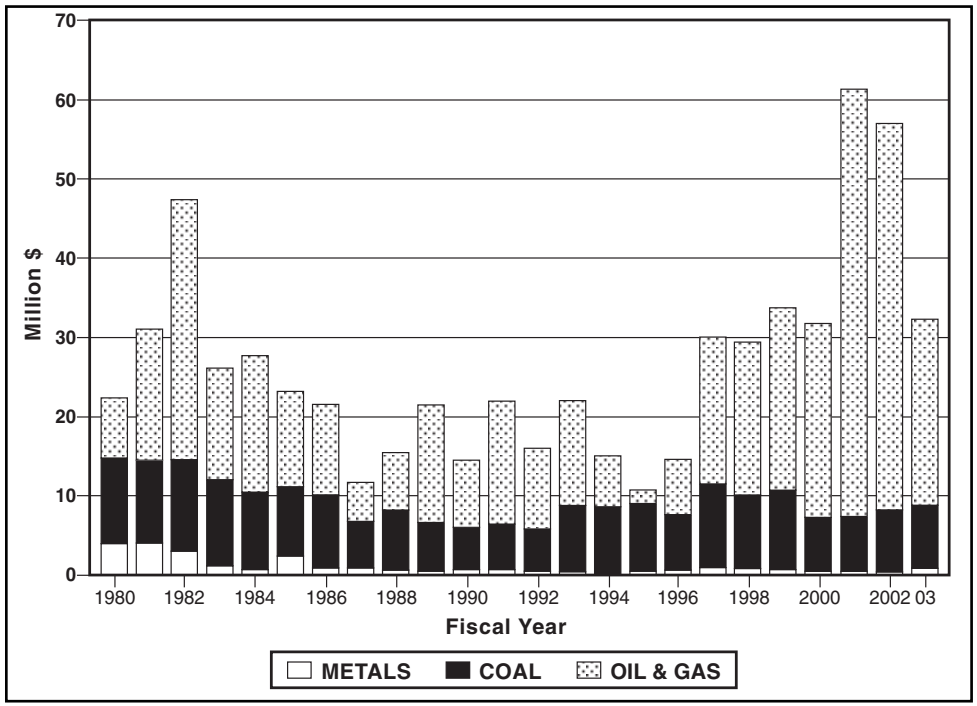


Figure 3. Colorado severance tax collections, 1980—2003. Note: The State of Colorado's Fiscal Year 2003 extends from July 2002 to July 2003. Thus, the low gas prices during the last half of the calendar year 2002 lowered the severance tax collections for fiscal year 2003.

FEDERAL MINERAL LEASE DISTRIBUTION

FEDERAL MINERAL LEASING ACT

- Net of administrative charges, returns 50% of rentals and royalties from federal lands in the state of origin.
- Directs that such funds be used by the states for planning, construction and maintenance of public facilities and services in areas of the state socially and economically impacted by mineral development.

COLORADO MINERAL LEASING FUND

- Colorado statute (CRS 34-63-102) directs that in the distribution of these funds priority shall be given to school districts and political subdivisions socially or economically impacted by the development or processing of the federal minerals.
- Distributes the amounts originating in each county as reported by the Federal government under the following "cascade" type of formula:

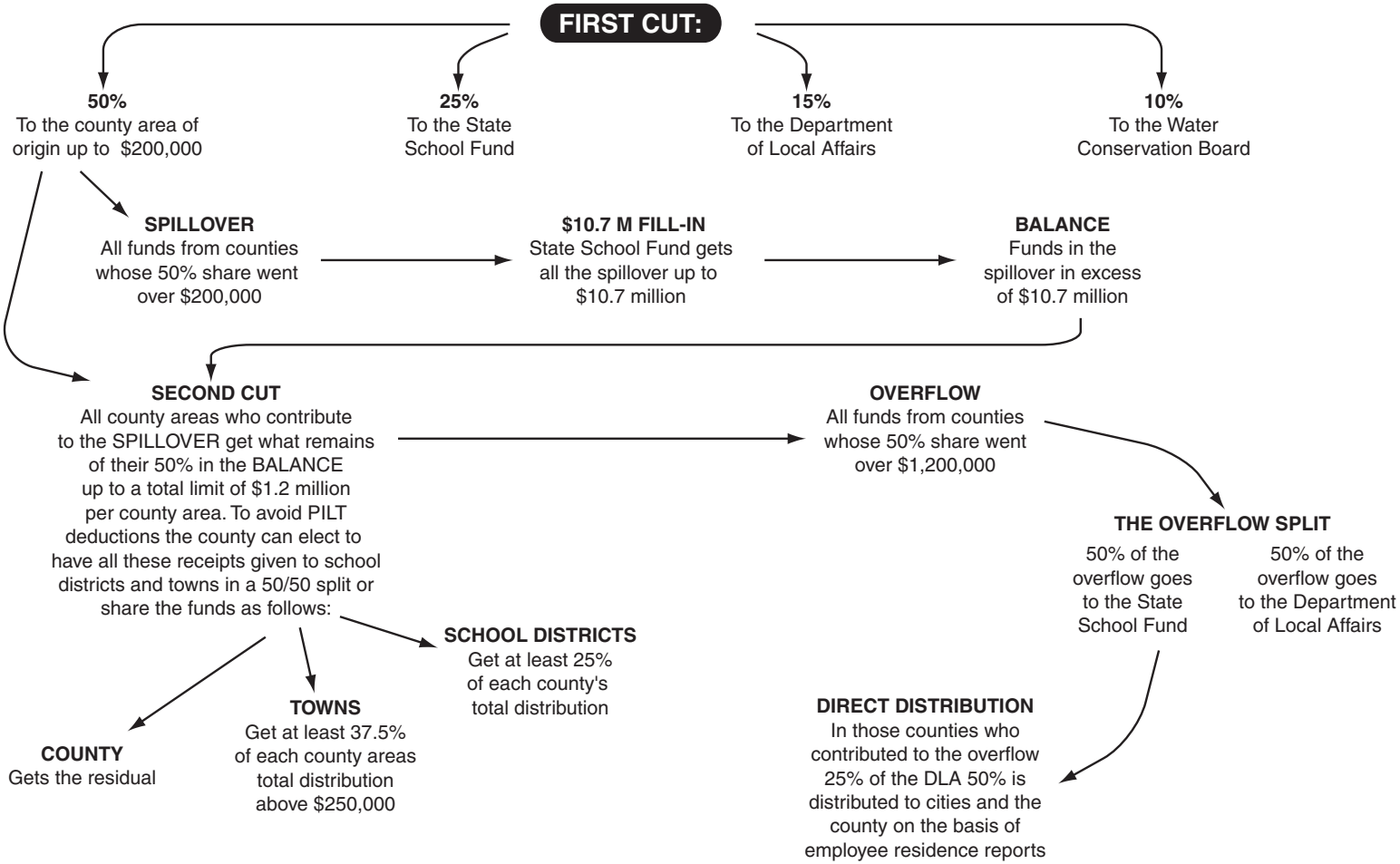


Figure 2b. Distribution of federal mineral lease revenues.

The University of Colorado's College of Business Administration estimates employment in the mineral and mineral fuel industries in 2003 to be 13,900 workers, a 6.1 percent increase from the 2002 level of 13,100 workers. Employment in mineral and mineral fuel industries has been increasing since 2000, ending a steady ten-year decline in mining and oil and gas employment from a 1990 level of 21,300 persons.

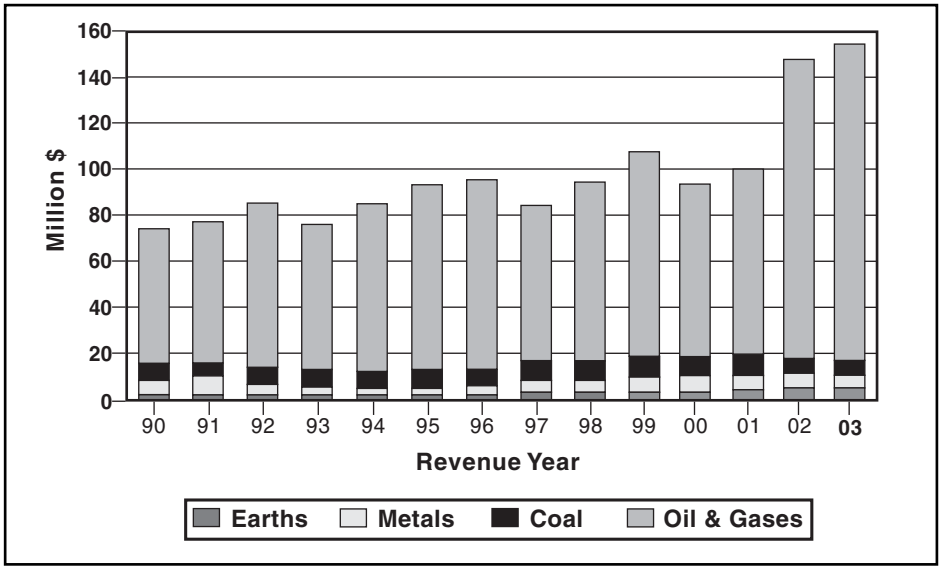


Figure 4. Property tax revenues from mineral properties, 1990—2003 (Colorado Dept. of Local Affairs).

GAS, OIL, AND CARBON DIOXIDE

By Genevieve Young

EXECUTIVE SUMMARY OF HYDROCARBON PRODUCTION STATISTICS

2003 Statistics	Estimated Production Value	Units**	Percent Change from 2002
Total natural gas production (including CBM)	1,011	BCF	6.9
Coalbed methane (CBM) production	503	BCF	5.2
Conventional gas production	508	BCF	8.5
Oil production	21.1	MMBO	3.4
Carbon dioxide production	307	BCF	4.1
Value of total gas production	$4,013.90	million	81.9
Value of CBM production	$2,004.90	million	78.9
Value of conventional gas production	$2,009.00	million	85.0
Value of crude oil production	$598.71	million	26.0
Value of carbon dioxide production	$64.47	million	4.1
Estimated Total Value of Production	**$4,677.08**	**million**	**70.5**

2002 Statistics	Production Value	Units**	Percent Change from 2001
Total natural gas production (including CBM)	946	BCF	13.8
Coalbed methane (CBM) production	478	BCF	11.7
Conventional gas production	468	BCF	16.1
Oil production	20.4	MMBO	3.0
Carbon dioxide production	295	BCF	-3.0
Value of total gas production	$2,207.04	million	-29.4
Value of CBM production	$1,120.46	million	-31.3
Value of conventional gas production	$1,086.58	million	-30.0
Value of crude oil production	$475.10	million	1.3
Value of carbon dioxide production	$61.95	million	-36.3
Total Value of Production	**$2,743.94**	**million**	**-22.2**

**Data compiled from Colorado Oil and Gas Conservation Commission (COGCC)*

***BCF = billion cubic feet of gas; MMBO = million barrels of oil*

INTRODUCTION AND REVIEW OF THE YEAR 2002

(In reading through this section, please refer to the glossary of selected terms and acronyms that has been included at the end of this section on page 20.)

This review includes the actual numbers for 2002 versus the estimated numbers included in last year's report. In 2002, the total value of produced natural gas, crude oil, and carbon dioxide (CO_2) was $2.74 billion, representing a 22 percent decline from the 2001 value (Figure 5). The value of produced natural gas (both conventional and CBM) accounted for 81 percent of this total, oil (17 percent), and CO_2 (2 percent).

Compared to 2001, gas prices were relatively stable in 2002 with an average price of $2.42 per MCF ($2.29 per MMBtu). Monthly prices fluctuated from a low of $1.79 per MCF in September to a high of $3.69 per MCF in December. Low prices at the beginning of the year were due to the unstable economy and an unusually warm winter in 2001–2002. The rising prices at the end of the year reflect increased demand due to the unusually cold, snowy winter in the eastern United States in 2002–2003. Oil prices averaged $23.52 per barrel for the year, increasing throughout 2003 from a low of $17.16 per barrel in January to a high of $27.11 in September.

The basis differential between the average Colorado gas price and the Henry Hub price averaged $0.97 per MMBtu in 2002, reflecting the continuing oversupply problem for Rocky Mountain producers in 2002. The average

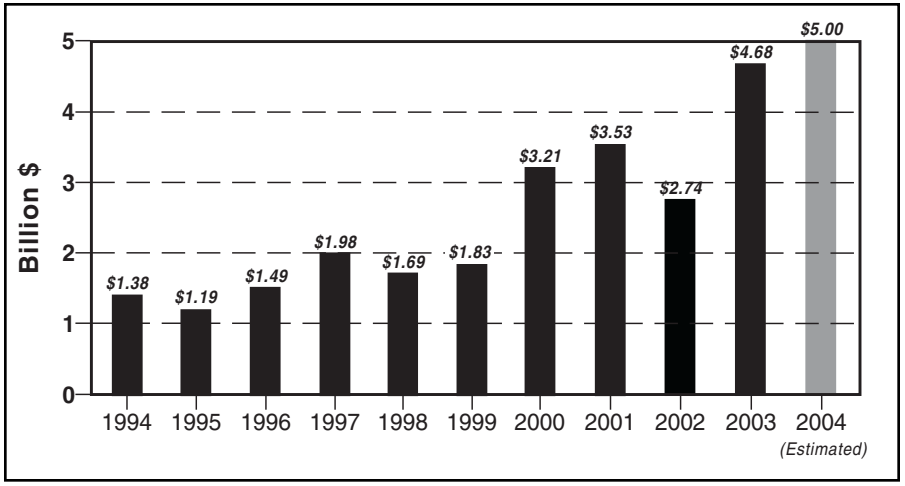


Figure 5. Colorado oil and gas production values 1994—2004 (COGCC).

monthly basis differential peaked in October 2002 at $1.85 per MMBtu.

Overview of Year 2003

Although the final numbers have not been completely reported to the Colorado Oil and Gas Conservation Commission (COGCC) for 2003, the estimated value of the oil, gas, and CO_2 produced in Colorado in 2003 is $4.68 billion, which represents more than a 70 percent increase over the production value of 2002. Of this total value, conventional natural gas and coalbed methane represents 86 percent, oil represents 13 percent, and CO_2 represents 1 percent. Estimated production volumes total 1,011 BCF of natural gas (which includes 503 BCF from CBM), 21.1 MMBO, and 307 BCF CO_2 (COGCC).

Natural gas prices in 2003 made a strong recovery over the low prices of 2001–2002; the average price of natural gas in 2003 was $4.10 per MCF ($3.86 per MMBtu), representing a 70 percent increase over the 2002 average of $2.42 per MCF. Monthly prices fluctuated from a high of $5.79 per MCF in March to a low of $3.68 per MCF in April. This price variation reflects an increase in natural gas demand as the economy started to recover, lower gas supplies, and the ability to deliver Rocky Mountain gas to wider markets with the expansion of the Kern River pipeline. Oil prices averaged $28.51 per barrel for the year, ranging from a high of $33.06 per barrel in February to a low of $25.55 per barrel in May. The oil price at the end of December 2003 was $29.66 per barrel.

The basis differential between the average Colorado gas price and the Henry Hub price increased from an average of $0.97 per MMBtu in 2002 to $1.17 per MMBtu in 2003. This increase resulted entirely from the Henry Hub gas spike to $9.28 per MMBtu in March 2003, yielding a basis differential of $3.82 per MMBtu for Colorado. Otherwise, the average basis differential for 2003 would have shown a slight decline from 2002 to $0.93 per MMBtu, reflecting the opening of the Kern River pipeline expansion in May 2002.

Colorado Petroleum Statistics for the Years 2002 and 2003

The following summary of Colorado petroleum statistics for the years 2002 and 2003 measures the ways in which the industry responded to lower oil and gas inventories during a period of demand growth, the beginning of economic recovery, and uncertainty about global economies.

Natural Gas and Coalbed Methane (CBM) Summary

Natural gas prices remained comparatively low ($2 to $3 per MCF) throughout most of 2002 with continued uncertainty surrounding the September 11, 2001 terrorist attacks and the continuation of a slow economy. Prices started a strong recovery in the last two months of 2002 and spiked at $5.79 per MCF in March 2003 (Figure 6). Prices have remained strong in the $4 to $5 per MCF range throughout 2003, reflecting a slow economic recovery stimulating demand combined with tighter gas supplies.

Total natural gas production in Colorado has increased steadily since coalbed methane production began in the late 1980s (Figure 7). Total natural gas for the state includes natural gas produced from either conventional oil/gas reservoirs or unconventional tight gas reservoirs, as well as the methane production from coal seam reservoirs. Coalbed methane production volumes have risen steadily since 1990, surpassing natural gas production in 1997 (Figure 8). However, conventional natural gas production has been catching up to coalbed methane production since 2000. The accelerated production growth in natural gas is in response to increased drilling in the gas-rich reservoirs of the Denver and Piceance basins in recent years. The combination of increasing natural gas production and a strong recovery in the price of gas yielded a significant increase in the production value of total natural gas production for 2003 (Figure 9).

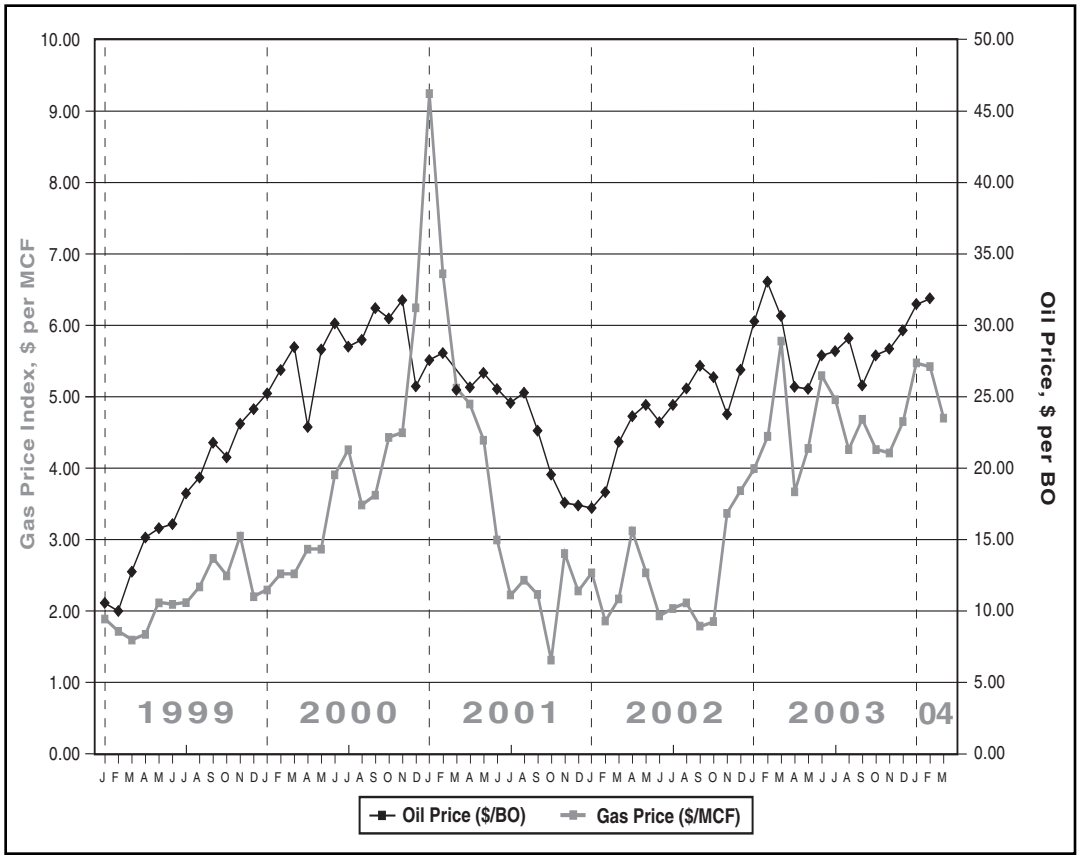
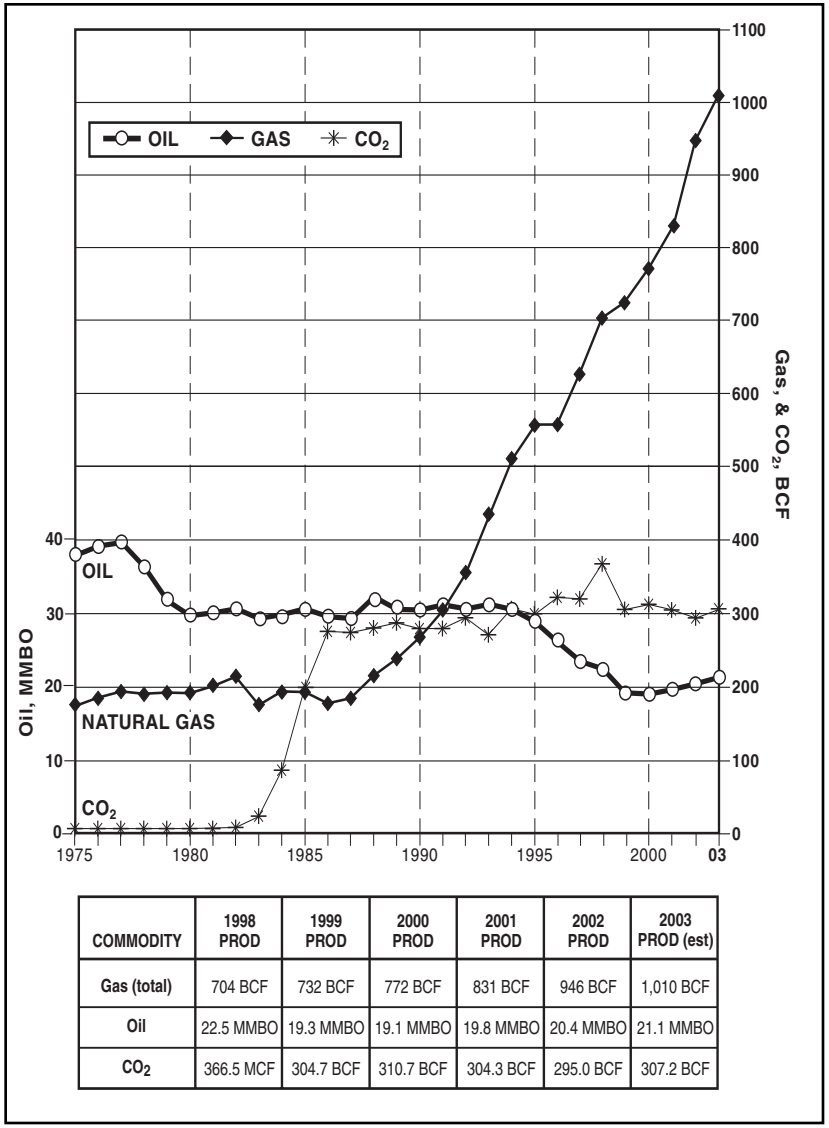
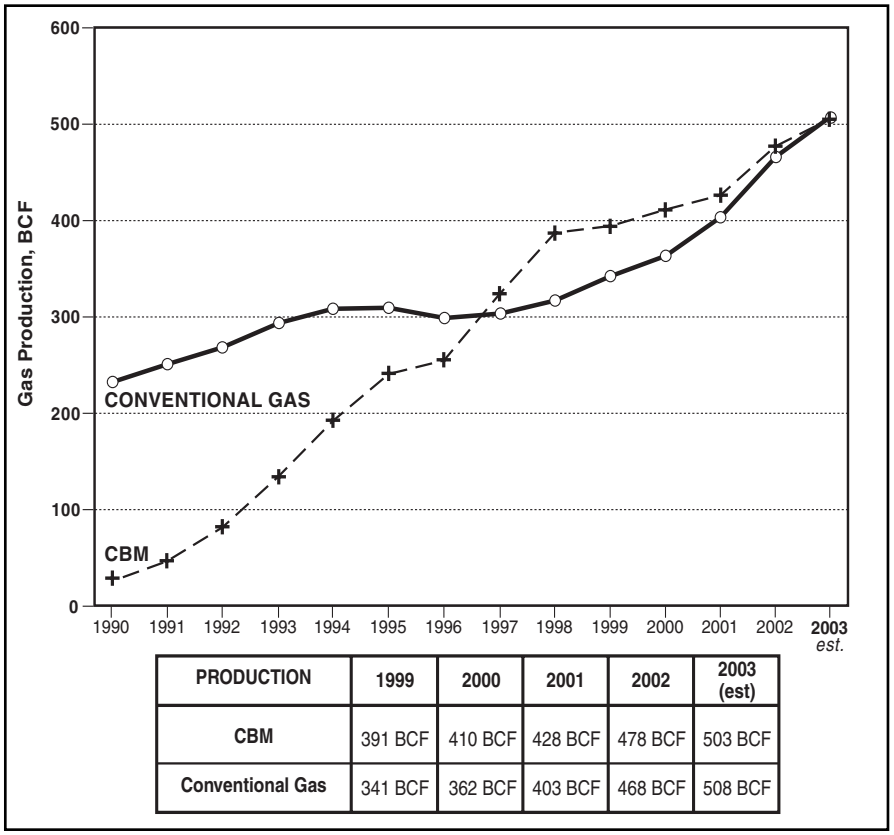


Figure 6. Colorado natural gas price index and weighted average oil price composite index, January 1999 to March 2004 (COGCC).



COMMODITY	1998 PROD	1999 PROD	2000 PROD	2001 PROD	2002 PROD	2003 PROD (est)
Gas (total)	704 BCF	732 BCF	772 BCF	831 BCF	946 BCF	1,010 BCF
Oil	22.5 MMBO	19.3 MMBO	19.1 MMBO	19.8 MMBO	20.4 MMBO	21.1 MMBO
CO_2	366.5 MCF	304.7 BCF	310.7 BCF	304.3 BCF	295.0 BCF	307.2 BCF

Figure 7. Colorado annual natural gas, oil and carbon dioxide production, 1975—2003 (COGCC).



PRODUCTION	1999	2000	2001	2002	2003 (est)
CBM	391 BCF	410 BCF	428 BCF	478 BCF	503 BCF
Conventional Gas	341 BCF	362 BCF	403 BCF	468 BCF	508 BCF

Figure 8. Coalbed methane and conventional natural gas production, 1990—2003 (COGCC).

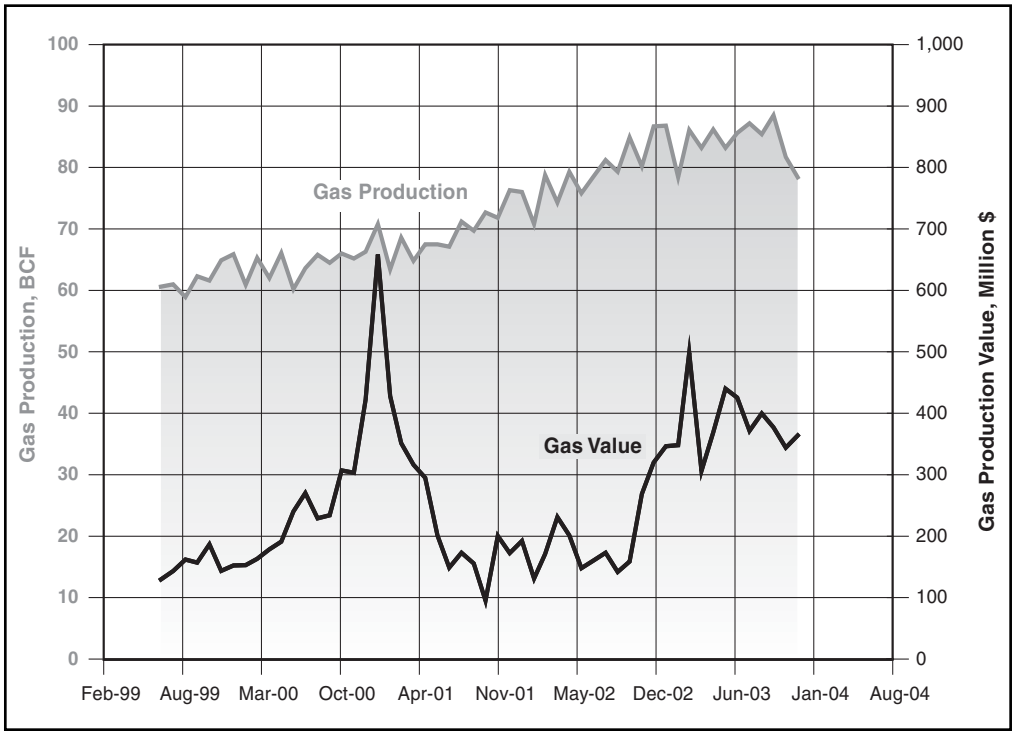


Figure 9. Monthly gas production and production value, 1999—2003 (COGCC).

Production numbers and values for 2002 in Colorado are summarized below for natural gas and coalbed methane (Figure 7):

- 946 BCF of natural gas and coalbed methane produced (13.8 percent increase from 831 BCF in 2001);
- 478 BCF of coalbed methane produced (included in total above) (11.7 percent increase from 428 BCF in 2001);
- $2.21 billion generated from natural gas and coalbed methane sales (29.4 percent decrease from $3.13 billion in 2001);
- $1.12 billion generated from coalbed methane sales alone (31.3 percent decrease from $1.63 billion in 2001).

Estimated production numbers and values for 2003 in Colorado are summarized below for natural gas and coalbed methane:

- 1,011 BCF of natural gas and coalbed methane produced (6.9 percent increase from 2002);
- 503 BCF of coalbed methane produced (included in total above) (5.2 percent increase from 2002);
- $4.01 billion generated from natural gas and coalbed methane sales (81.9 percent increase from 2002);
- $2.00 billion generated from coalbed methane sales alone (78.9 percent increase from 2002).

Crude Oil Summary

Oil production in Colorado has generally been declining or been stable for more than 30 years. For the past three years oil production has been increasing slightly. Annual oil production in 2003 was less than half of the 47.5 million barrels of oil (MMBO) in 1960 (Figure 7).

Production numbers and values for 2002 in Colorado are summarized below for crude oil:

- 20.4 MMBO produced (3.0 percent increase from 19.8 MMBO in 2001);
- $475 million generated from sales (1.3 percent increase from $469 million in 2001).

Estimated production numbers and values for 2003 in Colorado are summarized below for crude oil:

- 21.1 MMBO produced (3.4 percent increase from 2002);
- $599 million generated from sales (26 percent increase from 2002).

Carbon Dioxide Summary

Annual carbon dioxide (CO_2) production for 2002 totaled 295 BCF, a 3 percent decrease from the 2001 total of 304 BCF (Figure 7). The total value from CO_2 sales in 2002 was $62 million, a decrease of 36.3 percent from the 2001 value of $97 million.

Estimated production numbers and values for 2003 in Colorado are summarized below for CO_2:

- 307 BCF produced (4.1 percent increase from 2002);
- $64 million generated from sales (4.1 percent increase from 2002).

Coalbed Methane Summary

Coalbed methane production, which is typically included as a subset of total natural gas production, has become an increasingly more important resource for Colorado. Coalbed methane production volumes became significant enough in 1990 that they have been reported to the state as a separate commodity ever since. The production of this resource surpassed that of natural gas in 1997 and has remained a significant portion of Colorado's total natural gas production each year (Figure 8).

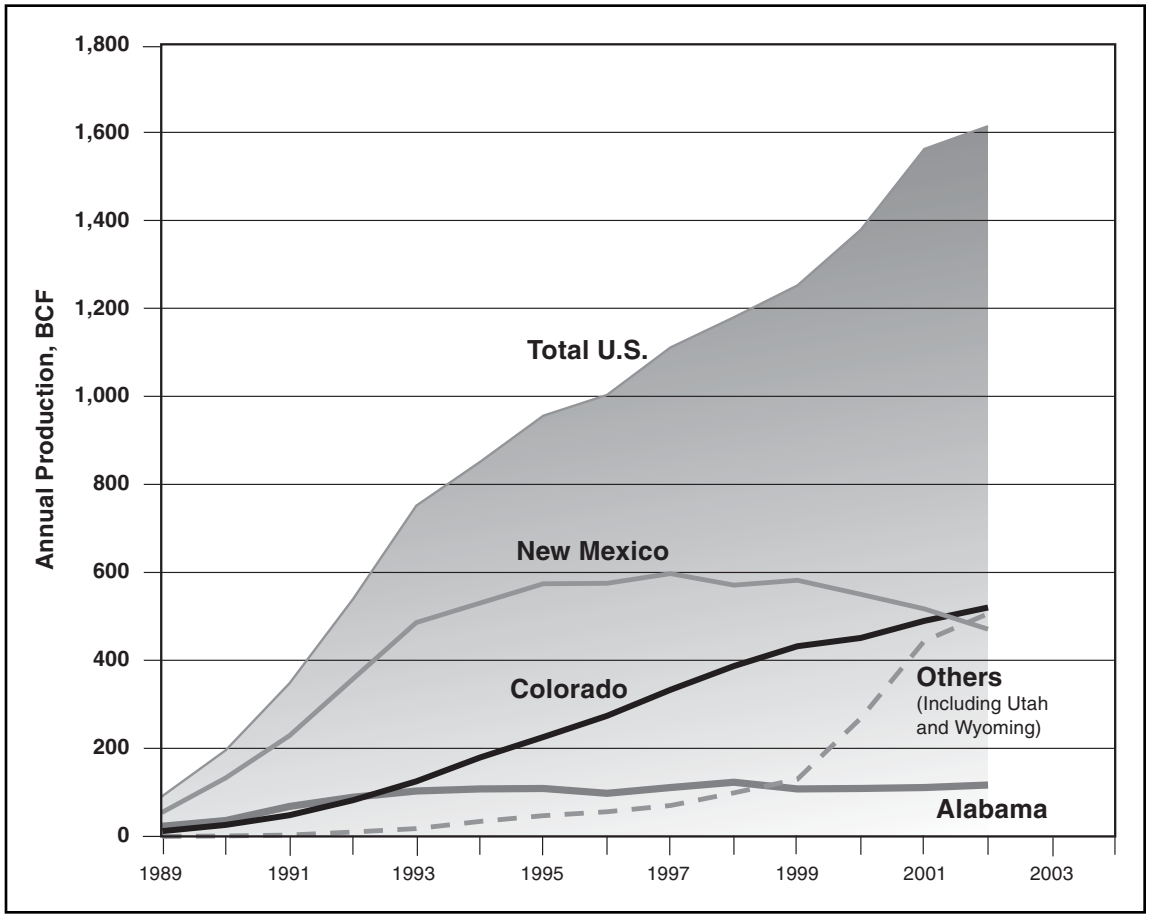


Figure 10. Annual coalbed methane production, 1989–2002 (DOE/EIA).

For the first time since the coalbed methane industry began in Colorado, the state ranked first among all others in both coalbed methane proven reserves and annual coalbed methane production in 2002 (Figure 10). Although production from the San Juan Basin Fruitland Formation coals has already peaked (see New Mexico's production curve in Figure 10), aggressive development in the Raton and Piceance basins have offset production decline in the Colorado portion of the San Juan Basin. Emerging plays in both Utah and Wyoming continue to have a dramatic impact on total U.S. coalbed methane production.

In 2002, 478 BCF (or 51 percent) of the total 946 BCF of natural gas produced in Colorado came from coalbed methane. Nationwide, coalbed methane accounted for 8.4 percent (1.6 TCF) of the total U.S. dry natural gas production of 19.1 TCF in 2002.

Table 1. National coalbed methane annual production and reserves in billion cubic feet, 1989—2002 (DOE/EIA). Note: EIA values differ from those of the COGCC. Others includes Wyoming and Utah until 2000, Oklahoma, West Virginia, Pennsylvania, Virginia, Kansas, and Montana.

YEAR	COLORADO		NEW MEXICO		UTAH		WYOMING		ALABAMA		OTHERS		TOTAL	
	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production
1989	1,117	12	2,022	56	NA	NA	NA	NA	537	23	0	0	3,676	91
1990	1,320	26	2,510	133	NA	NA	NA	NA	1,224	36	33	1	5,087	196
1991	2,076	48	4,206	229	NA	NA	NA	NA	1,714	68	167	3	8,163	348
1992	2,716	82	4,724	358	NA	NA	NA	NA	1,968	89	626	10	10,034	539
1993	3,107	125	4,775	486	NA	NA	NA	NA	1,237	103	1,065	18	10,184	752
1994	2,913	179	4,137	530	NA	NA	NA	NA	976	108	1,686	34	9,712	851
1995	3,461	226	4,299	574	NA	NA	NA	NA	972	109	1,767	47	10,499	956
1996	3,711	274	4,180	575	NA	NA	NA	NA	823	98	1,852	56	10,566	1,003
1997	3,890	333	4,351	597	NA	NA	NA	NA	1,077	111	2,144	70	11,462	1,111
1998	4,211	387	4,232	571	NA	NA	NA	NA	1,029	123	2,707	99	12,179	1,180
1999	4,826	432	4,080	582	NA	NA	NA	NA	1,060	108	3,263	130	13,229	1,252
2000	5,617	451	4,278	550	1,592	74	1,540	133	1,241	109	1,440	62	15,708	1,379
2001	6,252	490	4,324	517	1,685	83	2,297	278	1,162	111	1,811	83	17,531	1,562
2002	6,691	520	4,380	471	1,725	103	2,371	302	1,283	117	2,041	101	18,491	1,614

Production Trends for Colorado

With some interruptions, oil production in Colorado has been declining since 1960 when annual production was as high as 47.5 million barrels. The 1973–74 oil embargo resulted in a temporary recovery in the state's annual oil production; however, this recovery was short lived as production once again dropped dramatically between 1977 and 1980 (Figure 7). Colorado producers were able to achieve an impressively flat production profile for nearly 15 years through innovative hydrocarbon reservoir management strategies (secondary and tertiary recovery techniques, new fracture stimulations, recompletions, and infill drilling with improved drilling and completion technologies). However, the absence of new, large oil field discoveries to replace Colorado's dwindling reserve base resulted in another relatively sharp decline in the state's annual oil production from 1994–99. For the past five years, however, oil production has increased slightly.

Natural gas has become an increasingly important commodity in both Colorado and the United States due to its availability and reduced impact on the environment. In the last few years, the identification of significant natural gas reserves in Colorado and the greater Rocky Mountain Region has heightened the focus on exploration and development efforts. The Roan Plateau (Garfield County) in the Piceance Basin is estimated to contain one-third of Colorado's gas reserves. Some industry experts estimate 21 TCF in gas reserves for the 127,000 acre-Roan Plateau.

Coalbed methane continues to be an important resource for Colorado (Figure 8). The major coalbed methane producing areas include the San Juan and Raton basins. Exploration efforts continue in the Piceance, Sand Wash, and North Park basins. Although the coal seam reservoirs are relatively deep, the Piceance Basin is showing great promise as the next significant coalbed methane play for the state.

Colorado is the top producer nationally for coalbed methane (Table 1).

Annual production of carbon dioxide has been relatively flat, averaging 300 BCF per year since 1986 (Figure 7). No new naturally-occurring carbon dioxide reservoirs have been discovered or developed in Colorado in recent years; thus, existing reserves are gradually declining. Future demand for carbon dioxide for enhanced oil recovery may result in an increase in production.

Top County Producers

Thirty-five (or 54 percent) of Colorado's 65 counties produced natural gas including coalbed methane (Figure 11). The top three Colorado counties in annual gas production in 2003 have remained unchanged for the last several years (Table 2).

La Plata County remains number one with the bulk of the total gas production in 2003 attributed to the coalbed methane resources of the Late Cretaceous Fruitland Formation coals of the Ignacio–Blanco field in the San Juan Basin (Table 2). Other contributing gas reservoirs in the San Juan Basin include the Dakota and Mesaverde sandstones.

Major reservoirs in Weld County (second largest natural gas producer) include the Lower Cretaceous Muddy (J) and Upper Cretaceous D sandstones, as well as the Niobrara Formation carbonates. The Late Cretaceous Williams Fork Formation sandstones in Garfield County accounted for the vast majority of that county's gas production in 2003.

Thirty-two of Colorado's 65 counties produced oil in 2003 (Figure 11). The top three Colorado counties in both annual and cumulative oil production in 2003 were Weld, Rio Blanco, and Cheyenne counties (Table 3).

Table 2. Top three Colorado counties for natural gas production for 2003 (COGCC).

RATING	COUNTY	ANNUAL GAS PRODUCTION (BCF)	PERCENT OF ANNUAL COLO. PRODUCTION	CUM. GAS PRODUCTION (BCF)
1	La Plata	462	46	3,502
2	Weld	196	19	2,821
3	Garfield	141	14	843

Table 3. Top three Colorado counties for oil production for 2003 (COGCC).

RATING	COUNTY	ANNUAL OIL PRODUCTION (Mil Barrels)	PERCENT OF ANNUAL COLO. PRODUCTION	CUM. OIL PRODUCTION (Mil Barrels)
1	Weld	9.7	46	220
2	Rio Blanco	5.6	27	964
3	Cheyenne	2.0	9	85

Weld County continues to be the top oil producing county, with drilling permit applications nearly doubling since 2000 as a result of a major "refracing" effort that began in the Denver Basin in 2000. Weld County oil production is derived primarily from the Lower Cretaceous Muddy (J) and Codell sandstones, the Niobrara Formation carbonates, and the Sussex and Shannon sandstones.

Oil production in Rio Blanco County comes primarily from the Permo–Pennsylvanian Weber Sandstone in Rangely field, which is currently under an enhanced oil recovery program using the injection of carbon dioxide. Cheyenne County oil production is from Mississippian and Pennsylvanian-age sandstone and limestone reservoirs.

Montezuma County produced 284 BCF (or 93 percent) of the state's total carbon dioxide 2003. The Mississippian Leadville Limestone at the McElmo Dome field supplies carbon dioxide that is utilized in enhanced recovery programs in the Permian Basin of west Texas and eastern New Mexico. Dike Mountain and Sheep Mountain fields in the northwestern part of the Raton Basin in Huerfano County produced 7 percent of the state's total carbon dioxide in 2003. McCallum and McCallum South fields in the northeast part of the North Park Basin in Jackson County contributed less than 1 percent of the state's total carbon dioxide production in 2003.

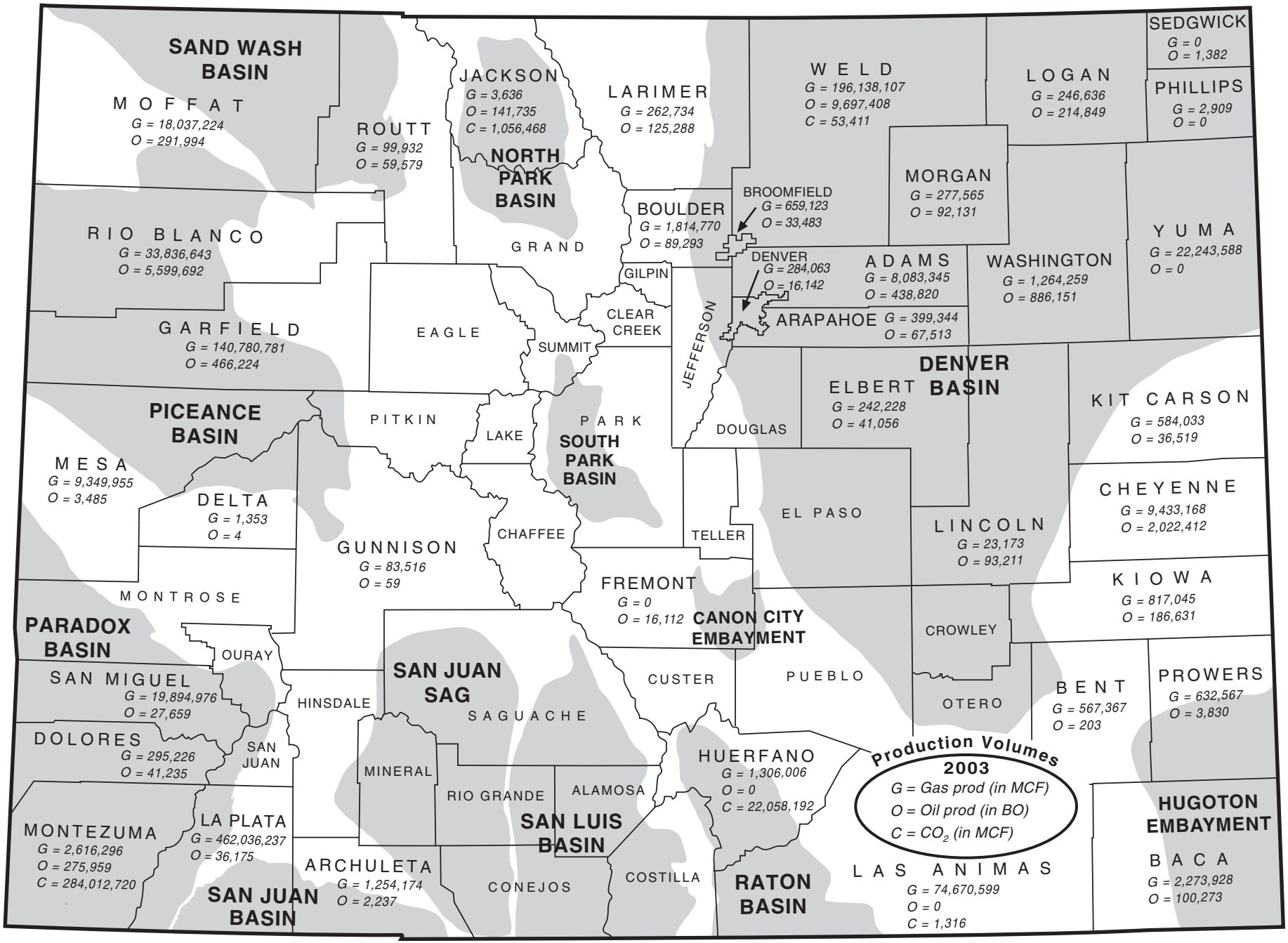


Figure 11. Production volumes for Colorado counties, 2003 (COGCC).

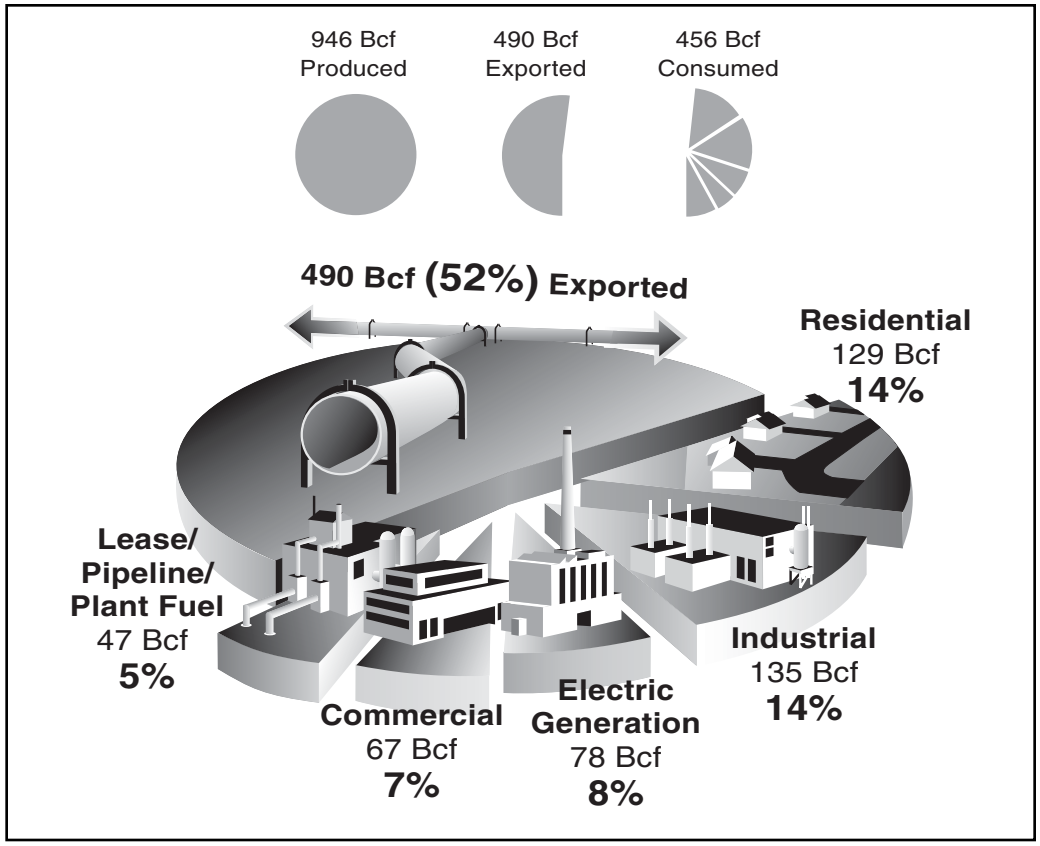


Figure 12. Colorado natural gas consumption by sector, 2002 (DOE/EIA).

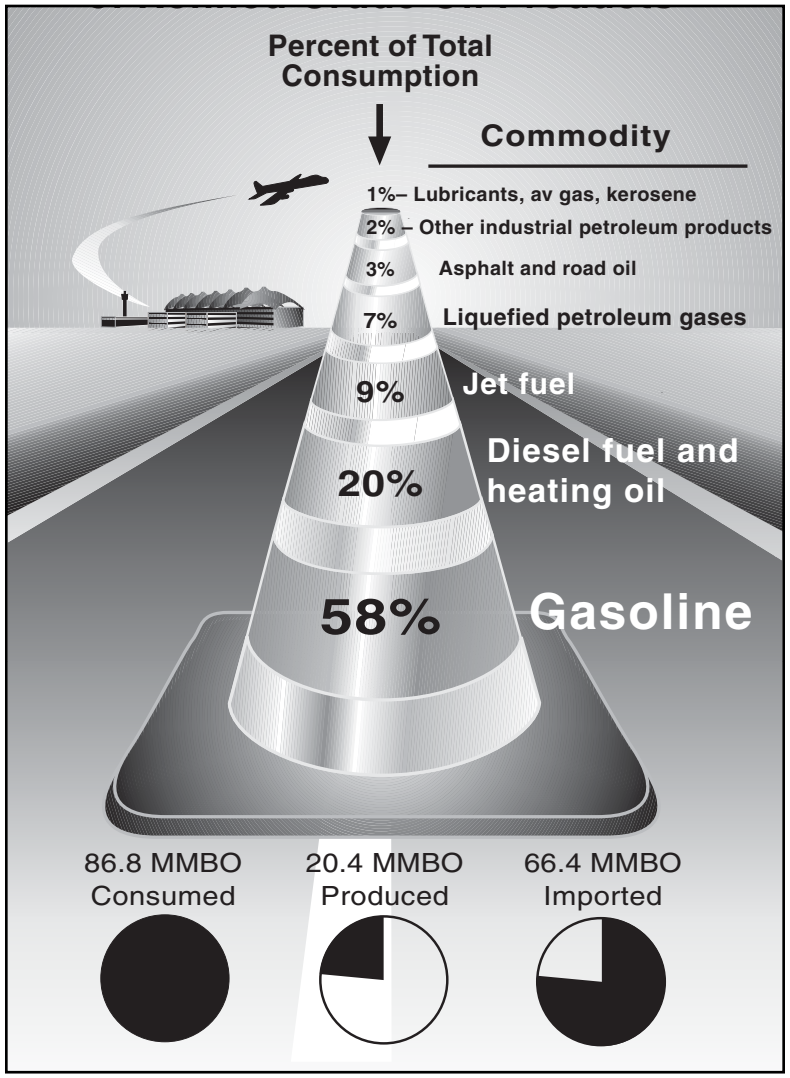


Figure 13. Colorado consumption of refined crude oil products by sector, 2002 (DOE/EIA).

CONSUMPTION

Colorado has been a net exporter of natural gas since 1991; Colorado produced nearly 1 TCF of natural gas in 2002 and exported more than half, or 490 BCF of the produced gas (Figure 12). In contrast, Colorado consumed more refined crude oil in 2002 than the state produced by more than a factor of four; that is, 86.8 million barrels were consumed but only 20.4 million barrels were produced (Figure 13). Petroleum and natural gas supply about two-thirds of the energy consumed in Colorado (Figure 14).

COMMODITY PRICING VALUE AND BASIS DIFFERENTIAL

In 2003, the total value for natural gas (including coalbed methane), crude oil, and carbon dioxide sold in Colorado was $4.68 billion, an all-time high, and a 71 percent increase over 2002 (Figure 5). It is estimated that these commodities will have a value of $5 billion in 2004, a further increase of 7 percent over 2003. This

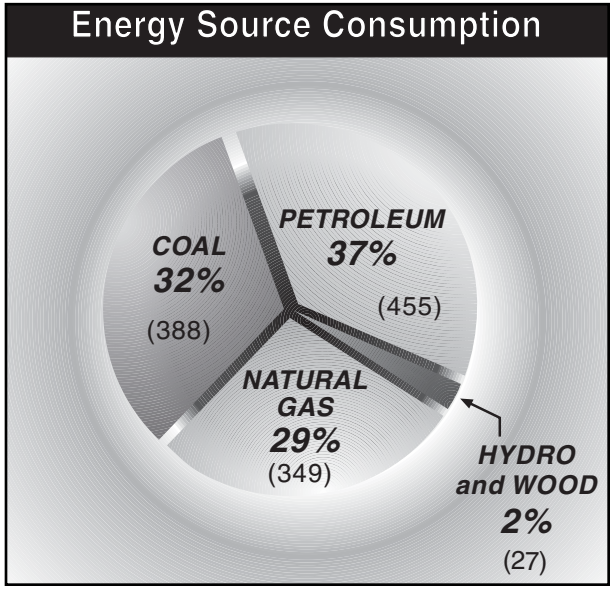


Figure 14. Colorado energy consumption by fuel source in trillion Btu, 2000 (DOE/EIA).

remarkable recovery in value is due in large part to the dramatic recovery in natural gas prices with continued increase in gas production (Figure 9) and the steady increase in oil prices offsetting the decline in oil production (Figure 6).

The basis differential between the price of natural gas at the Henry Hub distribution center in Louisiana and the price Colorado operators get for their natural gas began to slightly narrow in 2003. This resulted from the opening of the Kern River pipeline expansion in May 2003, allowing Colorado (and other Rocky Mountain) natural gas producers to compete with markets in California.

The basis differential reached a monthly maximum in March 2003 with a negative $3.82 per MMBtu (Figure 15). By December 2003, the differential had dropped to a negative $0.38 per MMBtu. Although cause-and-effect remains unclear, the dramatic spike in the basis differential in March 2003 coincided with a hundred-year snow storm in the Denver metropolitan area and the U.S. entry into war in Iraq.

Drilling Permits and Activity

Since 2000, there has been more than a two-fold increase in the number of drilling permits or "APDs" (Applications for Permit to Drill) in Colorado (Figure 16). This trend, which is expected to continue for the next few years, reflects the optimism created by higher natural gas prices, improved pipeline capacity and market distribution, and the opportunities awaiting in the state's emerging exploration areas such as the Piceance Basin.

The top five counties submitting APDs in 2003 were Weld, Garfield, Rio Blanco, Las Animas, and La Plata (Table 4). Activities in Weld County continued to focus on refracturing, infill drilling, and deepening existing wells. The major hydrocarbon reservoirs in Weld County are the Lower Cretaceous "J" Sandstone, Upper Cretaceous "D" Sandstone and the Codell Sandstone, and Niobrara Formation limestone. In Garfield County, activity focused on the Upper Cretaceous Williams Fork Formation tight (low permeability) sandstones and the Mesaverde Group Cameo-Fairfield coal group.

Drilling activity in Las Animas County centered exclusively on the Upper Cretaceous

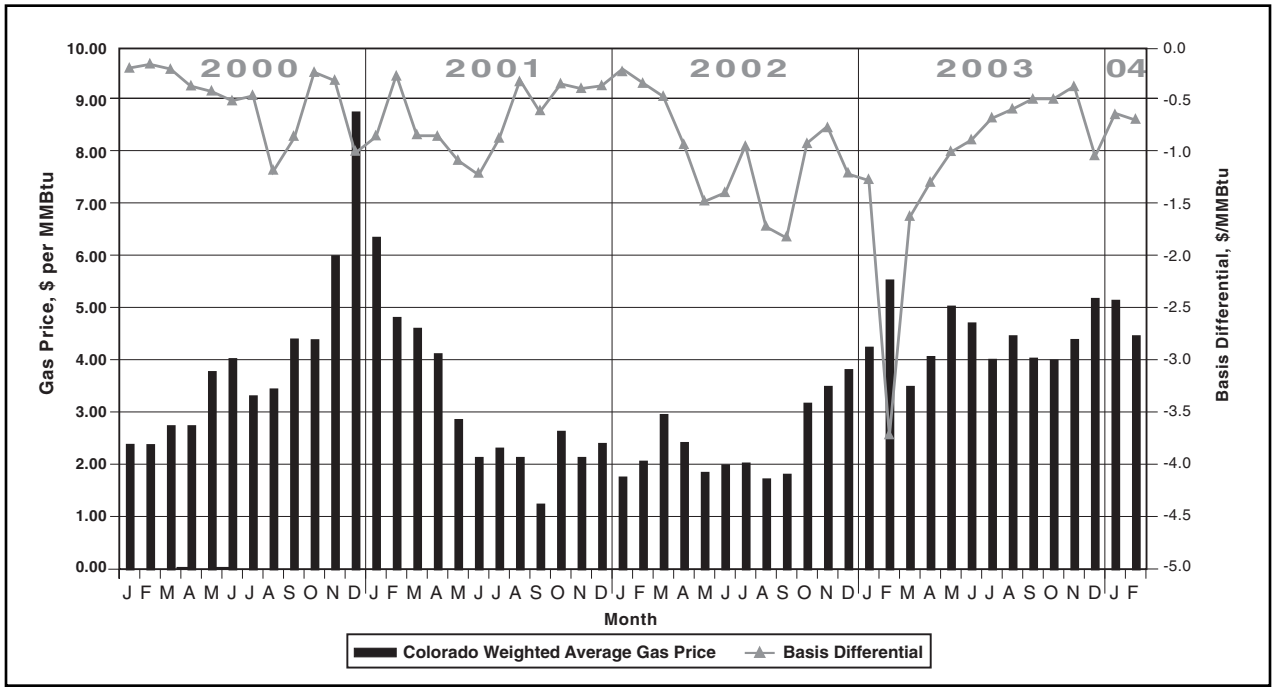


Figure 15. Colorado gas prices and basis differential with Henry Hub (COGCC).

Table 4. Top five Colorado counties submitting Applications for Permits to Drill (APDs), 1998—2003 (COGCC).

YEAR	Number 1	Number 2	Number 3	Number 4	Number 5	Total
1998	392 (Weld)	195 (Las Animas)	111 (Yuma)	95 (Garfield)	82 (La Plata)	1,157
1999	340 (Weld)	195 (Las Animas)	131 (Garfield)	118 (La Plata)	100 (Rio Blanco)	1,010
2000	509 (Weld)	268 (Las Animas)	213 (Garfield)	127 (La Plata)	89 (Rio Blanco)	1,529
2001	702 (Weld)	400 (Las Animas)	353 (Garfield)	205 (Yuma)	187 (Rio Blanco)	2,273
2002	760 (Weld)	362 (Garfield)	259 (Las Animas)	160 (Yuma)	105 (Rio Blanco)	2,007 (-12%)
2003	917 (Weld)	573 (Garfield)	184 (Rio Blanco)	183 (Las Animas)	163 (La Plata)	2,448 (+22%)

coals of the Raton and Vermejo Formations. The Raton Basin, which also extends into Huerfano County as well as into New Mexico, is one of the most active coalbed methane development areas in Colorado.

In Rio Blanco County, deeper Permo–Pennsylvanian Weber Sandstone permits are joined by permits to drill the shallower Upper Cretaceous Mesaverde Group sands and coals, sands in the Mancos Shale, and Tertiary Wasatch Formation coals and sands.

The vast majority of the wells drilled in Colorado are for the development of existing fields; 1,494 wells or 96 percent of the total wells drilled in Colorado in 2003 were classed as development (Table 5). The number of natural gas and coalbed methane wells drilled in Colorado continues to be significantly more than those drilled for oil; 1,428 gas wells compared to 31 oil wells drilled in 2003.

The average monthly drilling rig count in Colorado was 39 for 2003, a 40 percent increase over the average of 28 rigs in 2002; the Colorado monthly rig count has been running 40 or more for the last six months of 2003 (Figure 17). This relatively high rig count is in response to the higher oil and gas prices supporting increased drilling activity throughout the state; similar trends are being observed nationwide.

At the end of 2003, Colorado had 25,055 active wells. Half of the active wells were in Weld (10,094 or 40 percent) and La Plata Counties (2,503 or 10 percent) (Figure 18). Active well counts in both Rio Blanco and Garfield Counties are on the rise due to the increased drilling activity in the Piceance Basin (2,333 and 1,669 wells, respectively).

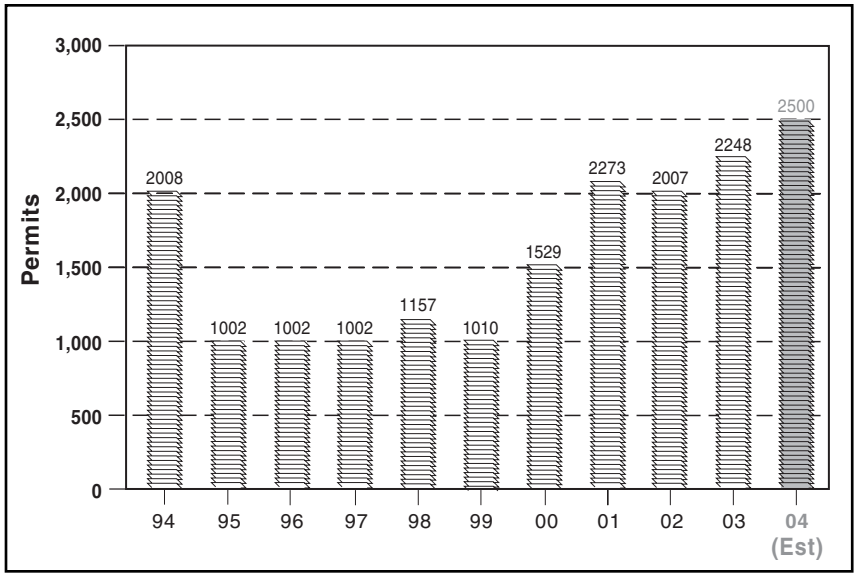


Figure 16. Colorado drilling permits, 1994—2004 (COGCC).

Employment Statistics

The Colorado Department of Labor and Employment projected approximately 8,000 jobs in 2003 for the oil and gas extraction sector of the petroleum industry in Colorado. Further, it is forecasted that this sector will see job growth of about 10 percent in 2004 (or 8,800). Generally, employment in this sector is directly correlated to energy prices.

Reserves

Colorado

Proven dry natural gas reserves in Colorado were estimated at 13,888 BCF at the end of

Table 5. Types of wells drilled in Colorado, 2000—2003 (Petroleum Information/Dwights LLC d/b/a HIS Energy Group, March 1, 2004).

COLORADO	Development Wells	Exploration Wells	Dry Holes*	Gas Wells	CBM Wells (Incl. in Col. 4)	Oil Wells	Horizontal Wells	Total Wells Drilled (Cols. 1+2 only)
2000	1,087	91	108	975	291	95	6	1,178
2001	1,546	129	168	1,465	463	42	3	1,675
2002	1,466	55	99	1,395	325	27	2	1,521
2003	1,494	55	90	1,428	304	31	8	1,549

*Includes service wells

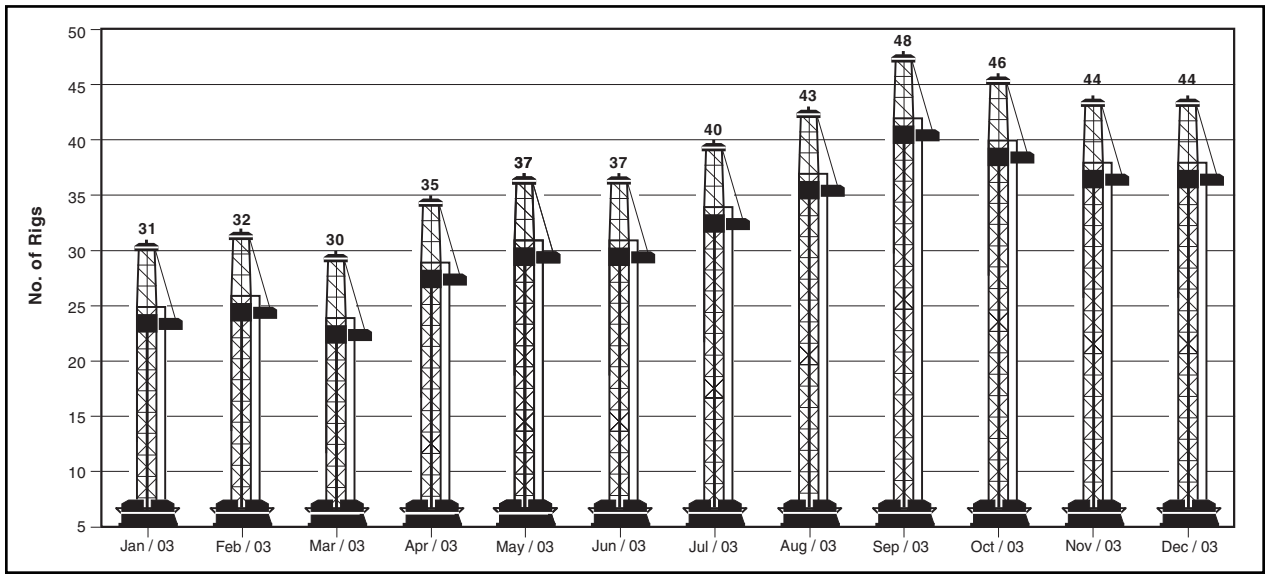


Figure 17. Colorado average monthly drill rig count in 2003 (Baker Hughes).

2002, an 11 percent increase from the 2001 total of 12,527 BCF (U.S. DOE/EIA): This volume accounts for 35 percent of the Rocky Mountain region's (Colorado, New Mexico, Utah, and Wyoming) proven gas reserves of 39.5 TCF. Colorado is ranked sixth in the United States in proven dry natural gas reserves. Of the approximate 187 TCF of proven reserves for U.S. natural gas, the Rocky Mountain region contains 21 percent of those reserves (Figure 19).

Proven crude oil reserves in Colorado were 214 MMBO at the end of 2002, up 9.2 percent from the 2001 total of 196 MMBO (U.S. DOE/EIA). Colorado's crude oil reserves constituted slightly less than 2 percent of the nation's total proven crude oil reserves of 22,677 MMBO at the end of 2002. Colorado was ranked 14th among the states in proven crude oil reserves in 2002.

FORECASTS

The U.S. DOE/EIA predicts an increase in oil and natural gas demand (and prices) in the United States for 2004 and 2005 as the economy continues to recover with a projected 2.9 percent growth rate. This growth is expected to result in a 2.6 percent increase in natural gas demand in 2004 and a continued rise in 2005 of about 0.4 percent. Natural gas production is expected to continue to expand through 2005 as natural gas well completions, which totaled an estimated 20,000 for the United States in 2003, continue to grow between 22,000 and 23,000 wells per year nationwide over the next two years. The Rocky Mountain Region is expected to be an area of considerable drilling activity to increase natural gas production from existing fields, and expanding into new areas. The expansion of the Kern River pipeline to

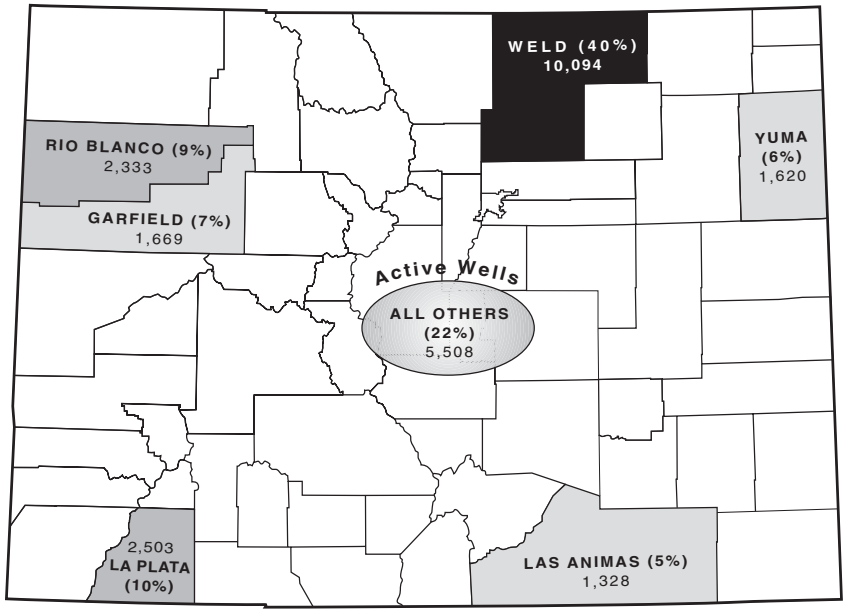


Figure 18. Active wells in Colorado counties, 2003 (COGCC).

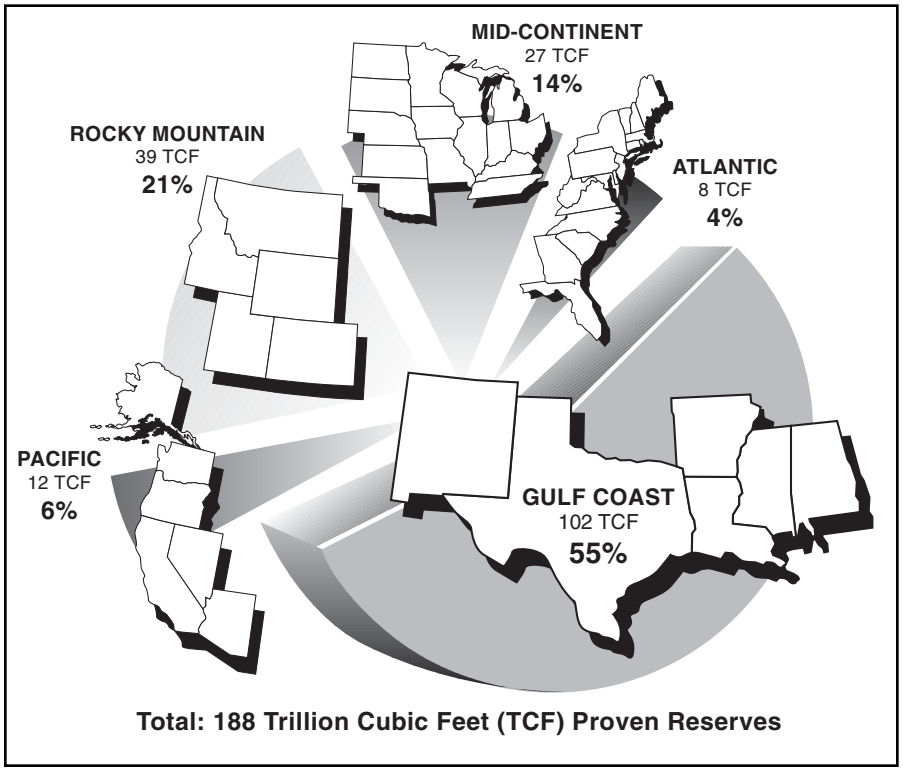


Figure 19. U.S. proven natural gas reserves by region in trillion cubic feet, 2002 (DOE/EIA).

take an additional 900 million cubic feet per day out of the Rocky Mountain market has already started to reduce the basis differential for gas. As a result, COGCC forecasts an average natural gas price in Colorado of $4.61 per thousand cubic feet for 2003–2004, the highest average since 2000–2001. As a consequence of the strong gas prices, COGCC is expecting to issue 2,500 new drilling permits in the coming year, bringing the active well count to 26,500.

The U.S. Geological Survey considers both the Piceance and San Juan basins among those areas with the highest priority for energy development in the western United States. In Garfield County, which includes much of the Roan Plateau in the Piceance Basin, some 550 wells will soon be added to the 1,800 already in place—31 percent increase (Figure 20). Such dramatic growth will present a number of challenges to the state's continued management and resolution of multi-use land issues in this area (Figure 21).

EIA reports that crude oil prices have been rising because of instability in the Middle East, low inventories and continued cold weather, and slow recovery in Venezuelan exports. World oil prices are expected to remain near $30 per barrel through the coming winter of 2004–2005. Prices will remain firm rather than declining, primarily due to OPEC's decision to lower oil production quotas. Commercial inventories are at five-year lows and are projected to remain slightly above observed five-year minimums throughout the 2004–2005 forecast period. Therefore, Colorado's crude oil prices should remain relatively high through the first quarter of 2004 and then gradually decline to about $27 per barrel by late 2004.

The petroleum industry and particularly the natural gas sector in Colorado may be poised for another boom. High natural gas prices are expected to drive resurgence in

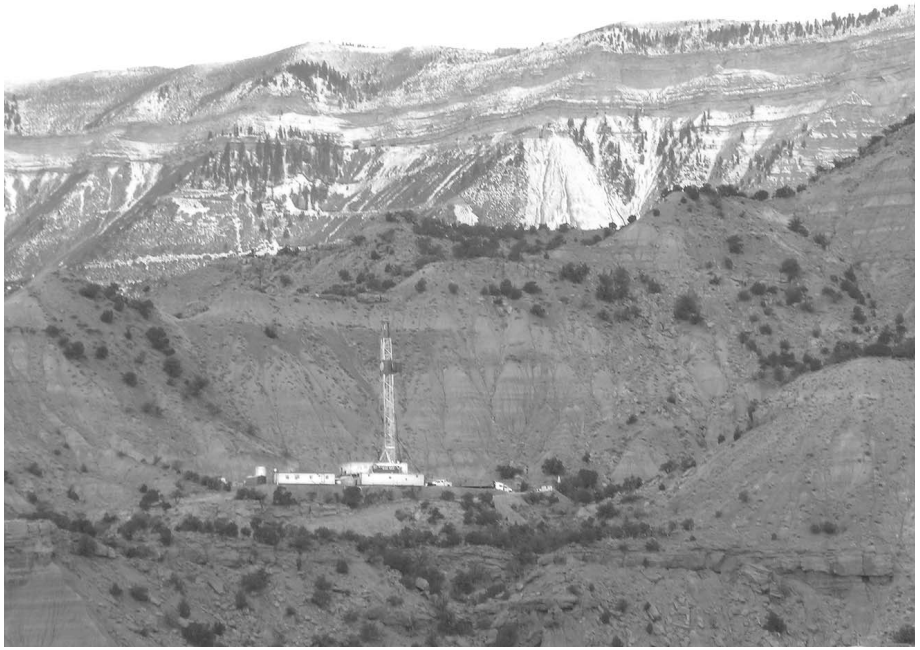


Figure 20. Drill rig near Roan Plateau in Garfield County, Piceance Basin (Photograph by Jim Cappa).

natural gas-directed activity in 2003–2004 following the downturn in 2002. Oil and carbon dioxide production should remain unchanged from the past several years. However, as most producers in Colorado are emphasizing natural gas, employment should increase in response to oil and natural gas prices and to the added pipeline capacity for delivery of natural gas to wider markets. Natural gas production, including coalbed methane, is forecasted to be 876 billion cubic feet in 2004. The implication for the consumer is that all energy prices will be relatively high. Gasoline is likely to be in the range of $1.50–$2.00 per gallon in 2004. This level of gasoline price may have a negative impact on tourism and agriculture in Colorado.

Items of Note

Colorado had a net increase of 1.4 trillion cubic feet of dry natural gas proved reserves in 2002. This was primarily from development of the Mamm Creek field in the Piceance Basin of northwestern Colorado (DOE/EIA).

In 2002, EnCana Oil and Gas (USA) added production and reserves in the Piceance Basin. This multi-zone, tight gas region is one of EnCana's leading growth areas. Wells typically intersect 3,000 feet of gas-charged, multi-formation reservoir. With an inventory of more than 1,000 known well locations, the area has great potential.

Development of coalbed methane fields and gas fields within the San Juan, Piceance, and Raton basins continued during 2003. As of early 2004, BP Amoco had completed 200 infill wells in the northern portion of the San Juan Basin. Many of these 160-acre well locations have encountered virgin (or nearly so) reservoir pressures in the Fruitland Formation coals. BP Amoco is planning to drill another 200 infill wells in the northern part of the San Juan Basin.

In mid-2003, the U.S. Federal Trade Commission approved the 2002-sale of

Figure 21. Drilling activities in the Piceance Basin (Photograph by COGCC).

ConocoPhillips' Commerce City oil refinery, along with 43 Phillips gas stations and other assets, for $150 million. The purchase was completed by the Canadian-based Suncor Energy Inc. who say they plan to spend up to $255 million in the next three years to meet new fuels legislation and enable the refinery to integrate Suncor sour crude blends.

The national focus on meeting high natural gas demand with simultaneously low inventories resulted in the Bureau of Land Management (BLM) initiating a policy review in mid-2003 for the purpose of eliminating current constraints related to oil and gas planning, leasing, and permitting in seven key areas; two of these areas are the San Juan and Piceance basins. The BLM is considering whether they need to revise or amend existing land-use plans to facilitate oil and gas exploration and development, based on the oil and gas industry rules mandated by the Energy Policy and Conservation Act of 2000. In August 2003, the White House Task Force on Energy Streamlining hosted a public meeting in Denver to solicit stakeholder input on the proposed formation of the Rocky Mountain Energy Council in an attempt to balance expedited energy development with land-use issues.

The Colorado School of Mines (CSM) acquired six laser technology patents from the Boeing Company in an attempt to bring a revolutionary method for using laser beams to drill oil and gas wells. This represents a major step in transferring military laser technology to beneficial civilian applications. CSM estimates that the costs could be several orders of magnitude less expensive than rotary drilling methods and have significantly less surface impact. The implications for Colorado and the greater Rocky Mountain Region could be dramatic if the research is successful.

GLOSSARY

(A)	Acquisition
APD	Application for permit to drill
Bbl	Barrel (of oil)
BBO	Billion barrels of oil
BCF	Billion cubic feet of gas (natural, CBM or CO_2)
BO	Barrel of oil
Btu	British Thermal Unit
CBM	Coalbed Methane—natural methane stored in coal
Cf	Cubic feet of gas
CGS	Colorado Geological Survey
CO_2	Carbon Dioxide
COGCC	Colorado Oil and Gas Conservation Commission
DOE	Department of Energy
DOE/EIA	Department of Energy/Energy Information Administration
(e)	Estimated value
IPAMS	Independent Petroleum Association of Mountain States
(JV)	Joint Venture
KW	Kilowatt: one thousand watts of electricity
KWh	Kilowatthour: a measurement of electricity
(M)	Merger
MCF	Thousand cubic feet of gas
MM	Million
MMBO	Million barrels of oil
MMBtu	Million British Thermal Units
MMCF	Million cubic feet of gas
MW	Megawatt: one million watts of electricity
OPEC	Organization of Petroleum Exporting Countries
Potential resources	Economic resources of crude oil and natural gas yet undiscovered, that are estimated to exist in favorable geologic settings.
Proved reserves	Quantities of crude oil and natural gas that geological and engineering data demonstrate, within reasonable certainty, to be recoverable in future years from known reservoirs under existing economic and operating conditions
PTTC	Petroleum Technology Transfer Council
Quad	Quadrillion: fifteen 0s Quad = 0.973 Trillion Cubic Feet of natural gas (TCF) or 170 million barrels of oil (MMBO)
TCF	Trillion Cubic Feet of gas
Therm	A unit of heating value equivalent to 100,000 Btus
Tight sands	Sands with low permeabilities that require induced fracturing to allow gas and oil to be produced

Modified from COGA report, December 2001, prepared by Thomas Hyde, p. 33

INDUSTRY WEB SITE LINKS	
American Gas Association (AGA)	www.aga.org
American Petroleum Institute (API)	api.org
American Wind Energy Association	awea.org
Colorado Department of Local Affairs (DOLA)	dola.state.co.us
Colorado Department of Natural Resources (DNR)	dnr.state.co.us
Colorado Geological Survey (CGS)	http://geosurvey.state.co.us
Colorado Office of Energy Conservation	state.co.us/oemc
Colorado Oil and Gas Association (COGA)	coga.org
Colorado Oil and Gas Conservation Commission (COGCC)	oil-gas.state.co.us
Department of Energy (DOE)	energy.gov
DOE/Energy Information Administration (EIA)	eia.doe.gov
Edison Electric Institute (EEI)	eei.org
Independent Petroleum Association of America (IPAA)	ipaa.org
Independent Petroleum Association of Mountain States (IPAMS)	ipams.org
Institute of Gas Technology Institute (GTI)	www.gastechnology.org
Interstate Natural Gas Association of America (INGAA)	ingaa.org
National Petroleum Association (NPC)	npc.org
Natural Gas Information and Educational Resources	naturalgas.org
Natural Gas Vehicle Coalition	ngvc.org
New Mexico Oil and Gas Association	nmoga.org
Petroleum Association of Wyoming	pawyo.org
U.S. Minerals Management Service (MMS)	mrm.mms.gov

COAL

By Christopher J. Carroll

INTRODUCTION

Coal mining is a strong and vital industrial sector of the Colorado economy. Over 94 percent of Colorado's electricity comes from coal-fired power plants. Spot market coal prices surpassed the $20 per ton mark recently for the first time in a decade. Remarkably, for the sixth time in seven years, Colorado coal mines broke the annual coal production record (Fig. 22). Mining in 2003 produced 35,880,773 short tons of coal from 12 coal mines, a two percent increase over the previous year's record. At $19 per ton, the value of Colorado coal produced in 2003 was $681 million, a ten percent increase over the 2002 value. These trends continue in 2004, as coal prices move upward and production for the first three months of the year is already 17 percent ahead of last year's production for the same time (Table 6).

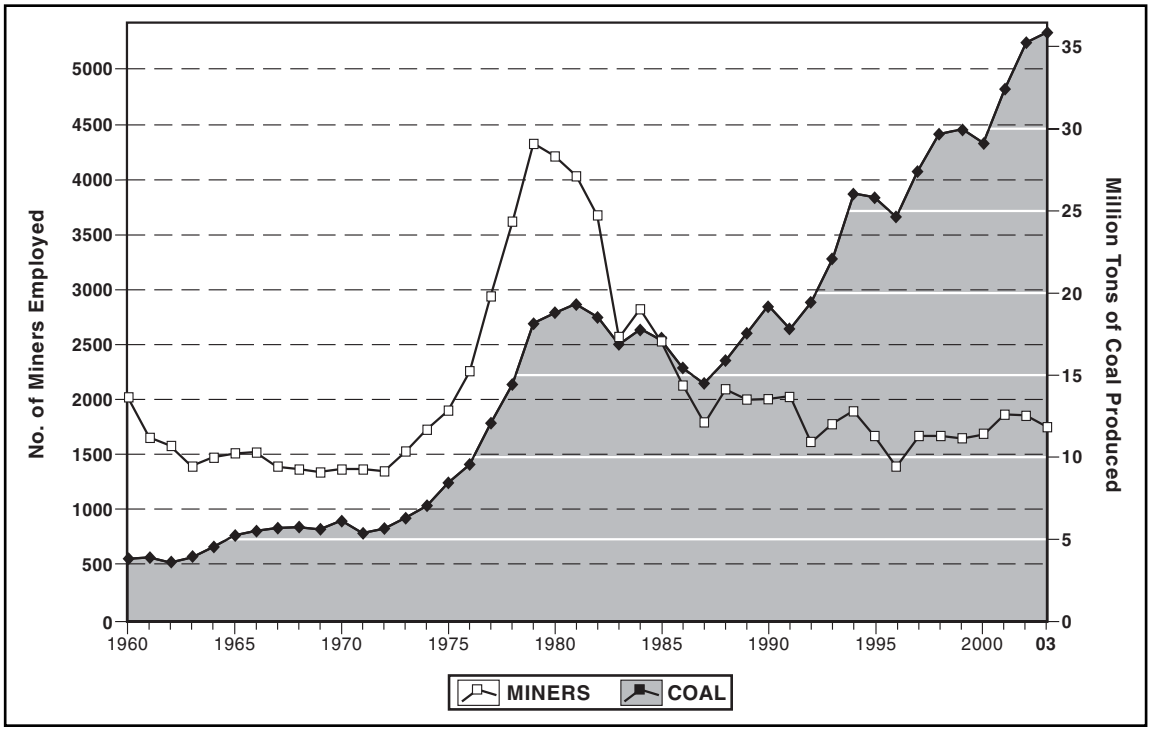


Figure 22. Coal production in Colorado, 1960—2003 (Colorado Division of Minerals and Geology [CDMG]).

COLORADO COAL IN THE NATIONAL MARKETPLACE

The demand for environmentally compliant western U.S. coal is strong, with annual coal production increasing at a fast pace. Table 6 shows the ten highest coal-producing states. Colorado now ranks sixth in coal production nationally. Colorado and Texas show double-digit increases in coal production over 2003 year to date (YTD). Montana and Wyoming also show significant coal production increases over last year. It can safely be said that the Rocky Mountain and Great Plains regions are now becoming the nation's main coal belt. Much of Colorado's increased coal production is due to Oxbow Mining's new Elk Creek Mine opening in early 2003 near Somerset. Other factors include increased demand for compliance coal as eastern U.S. coal supplies diminish, domestic production fluctuations due to Chinese coal mining stoppages, less U.S. coal mining due to several company bankruptcies and closures, and a colder than normal winter weather pattern in the northeastern U.S.. Whatever the reason there is currently a national short supply of compliance coal and short-term sales prices are moving upward, bringing Colorado's coal into high demand.

A report by *ABC News* on March 2, 2004 indicates that the nation's coal

Table 6. Top ten coal producing states for 2004 for the week ended 3/20/04 (EIA weekly data, March 20, 2004).

RANKING	STATE	YTD 2004	YTD 2003	PERCENT CHANGE FROM 2003
1	Wyoming	83,591	79,216	5.5
2	West Virginia	30,574	30,822	-0.8
3	Kentucky	23,981	26,274	-8.7
4	Pennsylvania	15,050	14,749	2.0
5	Texas	10,374	9,349	11.0
6	Colorado	8,446	7,226	17.0
7	Montana	7,882	7,547	4.4
8	Indiana	7,777	7,755	0.3
9	North Dakota	6,887	7,293	-5.6
10	Virginia	6,416	6,641	-3.4

Production in thousand short tons; YTD = year to date

industry is scheduled for a big comeback—after 25 years, the demand for cheap, affordable electricity is growing in popularity. Investment interests are now realizing coal is an inexpensive form of electrical power. Up to 94 new coal-fired power plants are planned in 36 states. This would generate over 62 gigawatts of additional electrical generation capacity, which would offset natural gas price fluctuations that have plagued the electricity generation sector in recent years. The downside, according to the article, is the increased burning of coal, which is perceived as an environmental liability.

Low-cost, low-emission natural gas plants sprang up everywhere in the 1990s, generating up to 19 percent of the nation's electrical supply. That was when gas was $2 per million-Btu. But now it is over $5.5 per million-Btu. Coal, after the large capital investment to build a plant, costs more like $1–$2 per million-Btu. To quote *ABCNews*, "That has put utilities in the position of paying more for the gas they burn to make power than they can get for the electricity it produces."

Not all economic aspects of the coal industry are up. The number of miners employed by Colorado mines decreased in the past year from 1,853 in 2002 down to 1,738 in 2003 (Fig. 22), a six percent decrease. This decrease in employment while coal production increases can only be explained as resulting from the significant increases in coal mine technology.

Coal as an inexpensive source of fuel is changing as well. The spot coal sales price increased to over $19 per ton in late 2003. As of March 2004, the current listed sales price for compliance coal (11,700 Btu, 0.8 percent sulfur) was $19.61 per short ton (Colorado Mining Association data). The Department of Energy's Energy Information Administration (EIA) weekly tracking shows Uinta Basin coal reaching the $25 per ton mark for some spot coal sales in March 2004. Colorado's coal sales market usually follows with the sale of Wyoming's Powder River Basin coal, but recently the Colorado spot sales have been more like eastern U.S. coal (Fig. 23). EIA states that there is a severe crimp in the coal supply chain to eastern markets now.

Coal production in Central Appalachia and the Illinois Basin is declining due to diminishing reserves of compliance coal and the exhaustion of thick, mineable seams. The large number of company bankruptcies, mine fires, and thinning seams has reduced production output in the eastern coal mines, which in turn has increased the price substantially in recent months. As Figure 23 shows, the price of Central and Northern Appalachia compliance coal has increased up to $55 per short ton in March 2004, more than doubling the price since February 2003. This may in turn create longer-term coal contracts that have not been seen in a decade.

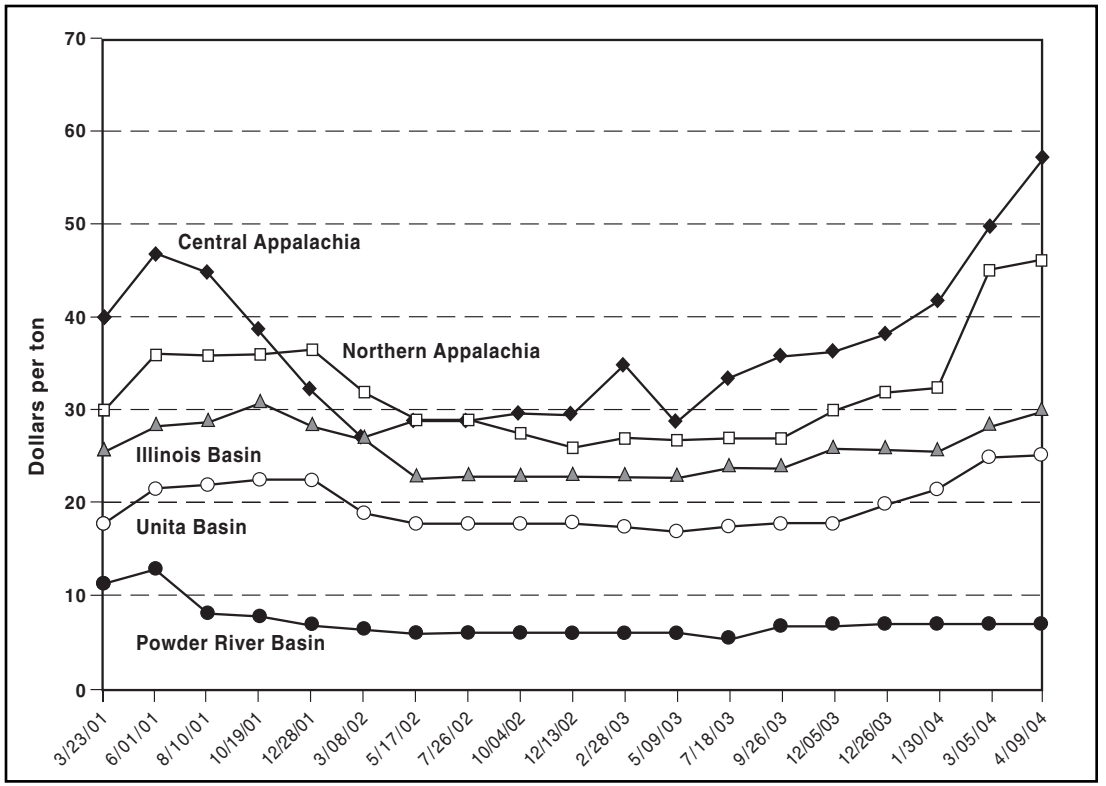


Figure 23. National average weekly spot prices sales for coal, nationally. Colorado coal falls into the Uinta Basin category. Source: DOE/EIA

At the 2004 Society of Mining, Metallurgy and Exploration (SME) annual meeting in Denver this February John T. Boyd and Associates gave a presentation quantifying the coal reserve dilemma in the Central Appalachian mining district. The authors believe that, due to permitting problems, financial stress, difficult mining conditions, and depleting reserves, the Central Appalachian area has less than five years of significant compliance coal production remaining. The reserves beyond that time are thin beds of higher sulfur coal. Only higher prices for coal will keep this area mining, but as it is now, there is little economic incentive to compete with western U.S. coal.

2003 Colorado Coal Supply

A combination of high demand, favorable mining conditions, a new large underground mine, and high prices enabled record-breaking coal production in 2003. Underground mining accounted for a record 27,226,759 short tons of coal produced from eight underground mines; 8,654,014 short tons were produced from four surface mines (see Fig. 24 for mine locations and Table 7 for mine statistics). Most of this coal was 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 21st and 26th respectively in the nation's list of largest mines, and 4th and 7th largest underground mines in the nation. The Bowie Mine No. 2 came in as the 33rd largest coal mine and the 9th largest underground mine (EIA 2002 data, *http://www.eia.doe.gov/cneaf/coal/page/acr/ table9.html*). Kennecott's Colowyo Mine, the largest surface mine in Colorado, is the nation's 34th largest coal mine and the 25th largest surface mine.

Coal was produced in eight Colorado counties last year. For the second year in a row the state's top coal producing county was Gunnison County (Fig. 25). Mountain Coal Company's West Elk Mine once again produced a large amount of coal with over 6 million short tons produced. The other Gunnison County mine, Sanborn Creek, produced only through February before shutdown. Oxbow Mining opened the Elk Creek Mine soon after closing Sanborn Creek Mine and produced over 4 million short tons in just eight months. Statewide the three highest coal-producing counties were, in order, Gunnison, Routt, and Moffat counties, which combine for over 78 percent of the state's coal production.

In terms of geologic coal regions, the large Uinta coal region was the leading producer with more than 23 million short tons from seven mines (Table 8). Somerset field in Gunnison and Delta counties was the most prolific coal field (Bowie No. 2, West Elk, Sanborn Creek, and Elk Creek) at 16,489,281 short tons produced (Table 9).

Distribution and Consumption

The main distribution method for coal in the west is rail. The Union Pacific Railroad is the largest coal transporter from western Colorado to the Front Range and midwestern states. Increased coal production has nearly maximized the capacity of these lines, and one particular bottleneck is the Moffat Tunnel near Winter Park. All western slope coal not consumed at power plants there is transported east through this portal.

Some Colorado mines haul coal by truck, such as King Coal, McClane Canyon, New Horizon, Trapper, and the Seneca Mines. These mines are smaller and mostly supply captive markets at nearby power plants or cement plants. Only King Coal in La Plata County transports coal by truck to out-of-state customers for cement manufacturing. Other mines have extensive conveyor systems to haul coal from the mine to a rail loadout, such as Bowie No. 2, Sanborn Creek, and Deserado mines. Most of the coal mines in the state supply steam coal via rail to customers in the Front Range and midwestern states. About 94 percent of the coal mined in Colorado is used for electricity generation, 4 percent for industrial plants, and 2 percent for residential and commercial use. Of the coal mines that use rail transportation, only Deserado Mine in Rio Blanco County supplies mine-mouth coal to a power plant operation outside of Colorado.

Less than half of the coal produced in-state is burned at Colorado power plants. Figure 28 depicts a flow diagram of coal distribution and consumption in Colorado. In 2002 (year for most recent data), only about 35 percent of Colorado produced coal was consumed in Colorado, with the remainder shipped out of state. A record 23 million tons of coal now leave the state annually. Most coal is shipped to states east of Colorado and burned at power plants as compliance coal, lowering the total sulfur content. According to EIA 2002 distribution data (*http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/o_co.html*) the leading Colorado coal exports were to Kentucky, Mississippi, Tennessee, Texas, Utah, and Illinois (Table 10). Kentucky purchased more than 4.5 million short tons of coal in 2002. West Elk Mine supplies power plants in Mississippi with more

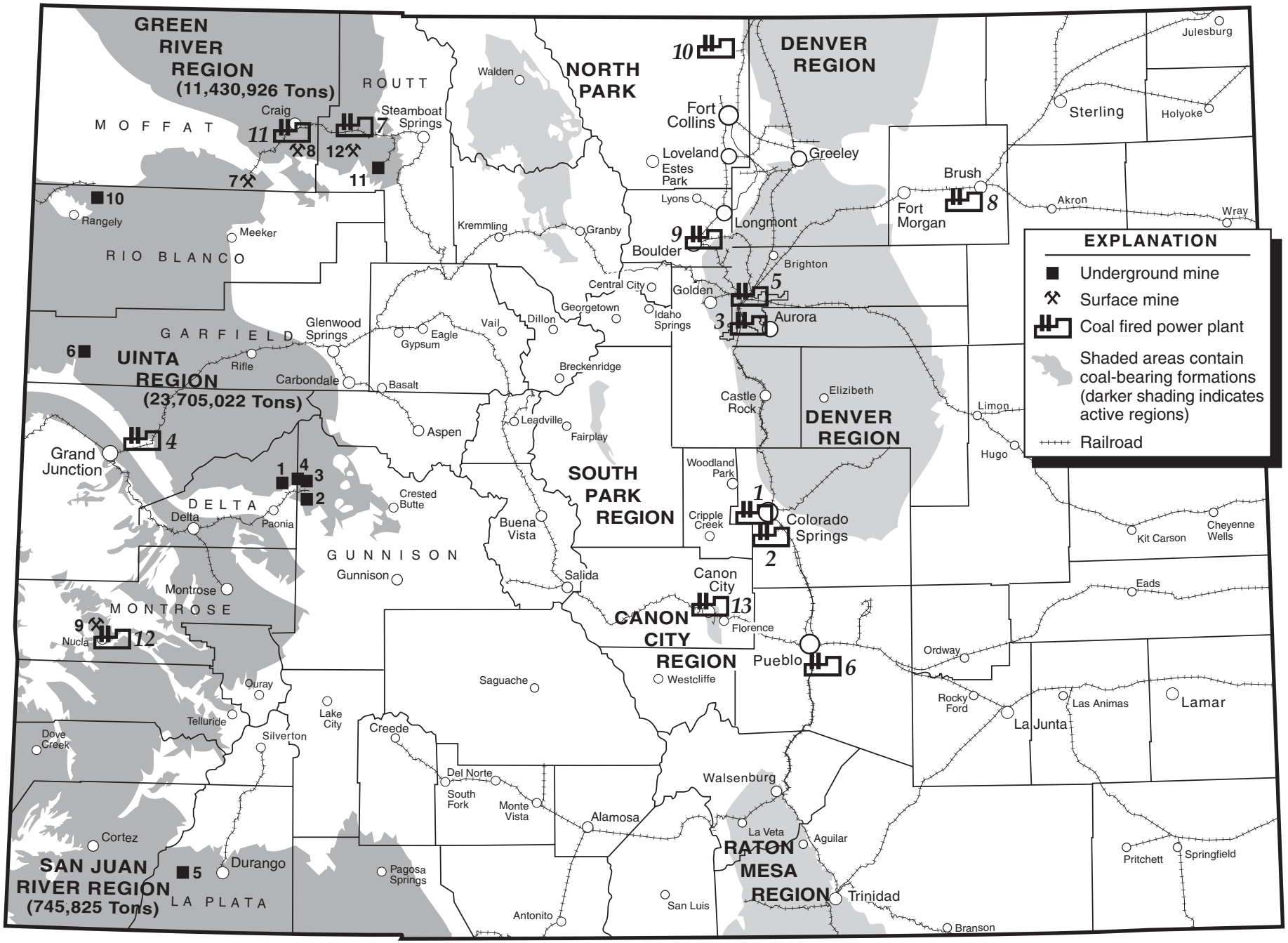
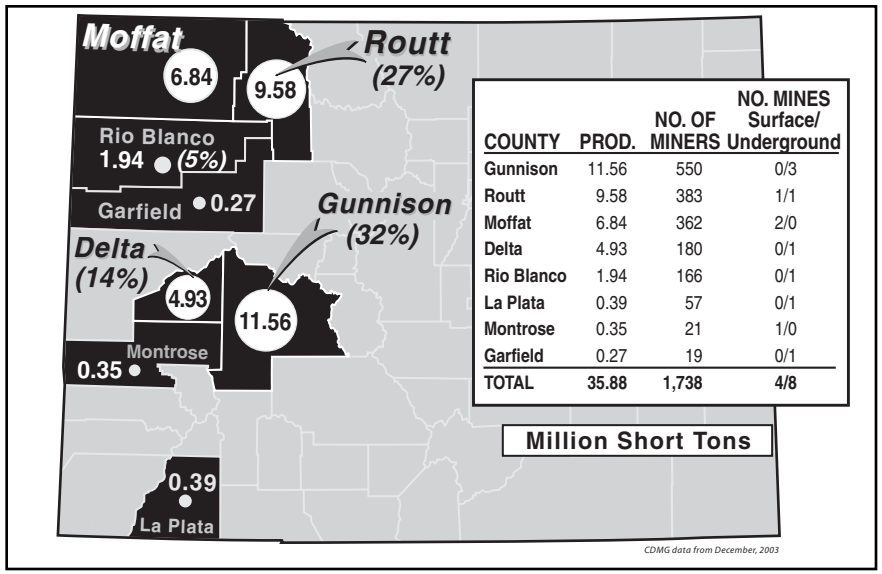


Figure 24. Locations of coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2003. See Table 7 for mine names, and Table 11 for power plant names.

Table 7. Colorado coal mine statistics, 2003 (see Fig. 24 for mine locations).

MINE NO.	MINE NAME	COUNTY	COAL REGION	COAL FIELD	OPERATOR	PARENT COMPANY	TWNSHP./ RANGE	GEOLOGIC FORMATION	PRODUCING BED NAMES	SEAM THICKNESS (ft)	BTU AVERAGE	MINE TYPE	MINING METHOD	2003 PROD.* (tons)	DEC. 2003 MINERS	SHIPMENT METHOD
1	Bowie No.2,3	Delta	Uinta	Somerset	Bowie Resources, Ltd.	Horizon Natural Resources	13S, 91W	Mesaverde	No. 2 in D seam, No. 3 in B seam	9 – 12	11,800	U	Longwall, continuous	4,926,457	180	Truck, rail
2	West Elk	Gunnison	Uinta	Somerset	Mountain Coal Co.	Arch Coal, Inc	13S, 90W	Mesaverde	B	14	11,650	U	Longwall, continuous	6,472,760	286	Rail
3	Sanborn Creek	Gunnison	Uinta	Somerset	Oxbow Mining, Inc.	Oxbow Power Co.	13S, 90W	Mesaverde	B, C	B 18 – 25, C 6.0 – 8.0	12,375	U	Longwall, continuous	494,482	0	Rail
4	Elk Creek	Gunnison	Uinta	Somerset	Oxbow Mining, Inc.	Oxbow Power Co.	13S, 90W	Mesaverde	B, C	B 18 – 25, C 6.0 – 8.0	12,375	U	Longwall, continuous	4,595,582	264	Rail
5	King Coal	La Plata	San Juan River	Durango	National King Coal, LLC	Alpha Natural Resources	35N, 11W	Upper Menefee	Upper Bed	4.3 – 6	12,500	U	Continuous	392,966	57	Truck
6	McClane Canyon	Garfield	Uinta	Book Cliffs	Lodestar Energy/CAM	Central Appalachian Mining (CAM)	7S, 102W	Mesaverde	Cameo B	4.4 – 9.4	11,250	U	Continuous	274,354	19	Truck
7	Colowyo	Moffat	Uinta	Danforth Hills	Colowyo Coal Co. (Kennecot)	Kennicott Energy & Coal Co.	4N, 93W	Williams Fork – Fairfield Coal Grp.	A – F, X, Y	8 beds 5.4 – 10.7	10,453	S	Dragline, shovels, dozers	4,998,615	236	Rail
8	Trapper	Moffat	Green River	Yampa	Trapper Mining, Inc.	PacifiCorp/Tri-State G&T/ Salt River	6N, 90W	Williams Fork – Upper Coal Grp.	H, I, L, Q, R	6, 5, 4, 13, 4	9,850	S	Dragline, shovels, hyd. excav.	1,845,061	126	Truck
9	New Horizon	Montrose	San Juan River	Nucla–Naturita	Western Fuels Colorado	Tri-State G&T Assoc.	46N, 15W	Dakota	Upper & Lower Coal Beds	0.75 – 1.25 4.0 – 6.5	10,800	S	Shovels, dozers	352,859	21	Truck
10	Deserado	Rio Blanco	Uinta	Lower White River	Blue Mountain Energy, Inc.	Deseret Generation and Transmission	3N, 101W	Williams Fork	B Seam	7.0 – 16.0	10,000	U	Longwall, continuous	1,942,772	166	Rail
11	Twentymile (Foidel Creek)	Routt	Green River	Yampa	Twentymile Coal Co. (RAG American Coal)	RAG American (now Peabody Energy 3/04)	5N, 86W	Williams Fork – Middle Coal Grp	Wadge	7.0 – 11.0	11,250	U	Longwall, continuous	8,127,386	276	Rail
12	Seneca II-W, Yoast	Routt	Green River	Yampa	Seneca Coal Co.	Peabody Holding Co., Inc.	5N, 87W	Williams Fork – Middle Coal Grp	Wadge, Wolf Crk., Sage Cr	8.9 – 14.2, 15 – 20.4, 3.4 – 5.4	11,908 – 12,581	S	Dragline, loaders	1,457,479	107	Truck, rail
TOTAL														35,880,773	1,738	

*Shaded areas indicate new annual production record. U = underground mine S = surface mine



COUNTY	PROD.	NO. OF MINERS	NO. MINES Surface/ Underground
Gunnison	11.56	550	0/3
Routt	9.58	383	1/1
Moffat	6.84	362	2/0
Delta	4.93	180	0/1
Rio Blanco	1.94	166	0/1
La Plata	0.39	57	0/1
Montrose	0.35	21	1/0
Garfield	0.27	19	0/1
TOTAL	35.88	1,738	4/8

Figure 25. Colorado coal production by county, 2003 (CDMG).

Table 8. Coal production by coal region, 2003 (CDMG).

COAL REGION	PRODUCTION	NO. OF MINERS (Dec. 03)	NO. OF MINES (Surface/ Underground)	MINES
Green River	11,429,926	509	2/1	Foidel Creek, Seneca (Seneca II-W and Yoast), Trapper
San Juan River	745,825	78	1/1	King Coal, New Horizon
Uinta	23,705,022	1,151	1/6	Colowyo, McClane Canyon, DeseradoBowie No. 2, Sanborn Creek/Elk Creek, West Elk
TOTAL	**35,880,773**	**1,738**	**4/8**	

Table 9. Coal production by coal field, 2003 (CDMG coal figures, 2003).

COAL REGION	PRODUCTION	NO. OF MINERS (Dec. 03)	NO. OF MINES (Surface/Underground)	MINES
Yampa	11,429,926	509	2/1	Foidel Creek, Seneca (Seneca II-W and Yoast), Trapper
Nucla/Naturita	352,859	21	1/0	New Horizon
Durango	392,966	57	0/1	King Coal
Danforth Hills	4998615	236	1/0	Colowyo
Lower White River	1,942,772	166	0/1	Deserado
Book Cliffs	274,354	19	0/1	McClane Canyon
Somerset	16,489,281	730	0/4	Bowie No. 2, West Elk, Sanborn Creek, Elk Creek
TOTAL	**35,880,773**	**1,738**	**4/8**	

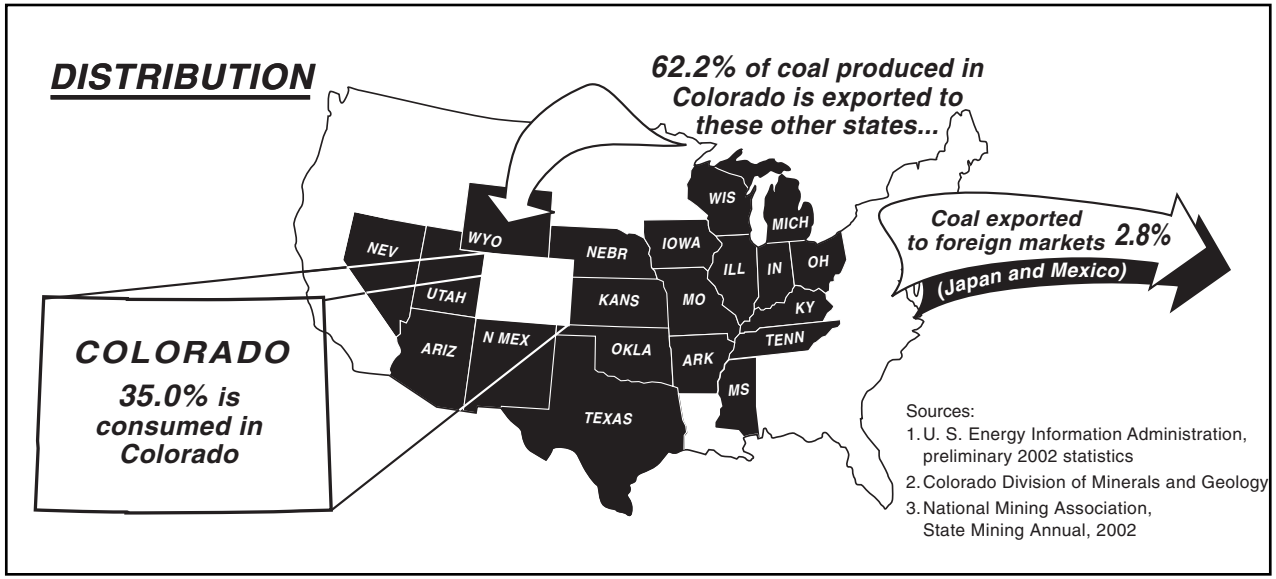


Figure 26. Distribution of coal in Colorado, 2002 (EIA, 2002 most recent data).

than 3 million tons annually. Most of this coal is used as steam coal, but some is shipped for cement manufacturing and other industrial uses, mostly in Texas and Iowa. Of noteworthy interest is that Colorado no longer produces any coking coal. Foreign exports are not a large part of the Colorado coal market, however some 843,000 short tons were shipped to Mexico and Japan in 2002, but no Japanese sales were reported in 2003 (Table 10).

Colorado imports coal as well. About 10.5 million short tons of coal were imported from Wyoming to power plants within Colorado in 2002 (EIA 2002 distribution data to Colorado, *http://www.eia.doe.gov/ cneaf/coal/page/coaldistrib/d_co.html*). Over 20,000 short tons of anthracite were imported from Pennsylvania as well. Less expensive Wyoming coal is sold to power plants on the Front Range. Rawhide Power Plant, in northern Colorado, is close to the Wyoming border and uses only Powder River Basin coal. On the consumer side, a total of 21.5 million short tons of coal were consumed in Colorado in 2002 for steam power plants, industrial plants, and residential and commercial users.

A total of 18.2 million short tons of coal were consumed at coal-fired power plants in Colorado in 2003 (Table 11). This figure is down 5 percent from 2002. The amount of Colorado coal burned at Colorado power plants increased to about 58 percent.

Minnesota-based Xcel Energy, which owns or operates seven coal-fired power plants in Colorado, is the largest corporate consumer of coal in Colorado, and the 27th largest coal consumer in the nation. Tri-State Generation and Transmission's Craig Station is the state's largest coal-fired electrical generating station. In 2003 the plant consumed 4.78 million short

Table 10. Colorado coal distribution (DOE/EIA 2002 data).

STATE OF DESTINATION	ELECTRIC UTILITIES Steam, Coal	COKE PLANTS	INDUSTRIAL PLANTS	RESIDENTIAL/ COMMERCIAL	TRANSPORTATION	CHANGE 2001	TOTAL
Arizona	976	0	133	0	Rail, truck, pipeline	+15	1,109
Arkansas	0	0	175	0	Rail	+51	175
Colorado (In-state)	10,416	0	400	227	Rail, truck	-631	11,043
Illinois	1,838	0	94	0	Rail, river	+286	1,932
Indiana	0	0	227	0	Rail	+36	227
Iowa	189	0	374	0	Rail, river	-97	563
Kansas	201	0	180	0	Rail	-1,080	381
Kentucky	4,526	0	0	0	Rail, river	+297	4,526
Michigan	388	0	85	0	Rail, Great Lakes	-700	473
Mississippi	3,022	0	0	0	Rail	+1,249	3,022
Missouri	35	0	168	0	Rail, river	-223	203
Nebraska	0	0	114	7	Rail	-41	121
Nevada	283	0	0	0	Rail	(new)	283
New Mexico	0	0	72	0	Truck	0	72
Ohio	583	0	0	0	River	558	583
Oklahoma	0	0	14	0	Rail	(new)	14
Tennessee	2,864	0	7	0	Rail, river	+1,392	2,871
Texas	1,760	0	710	1	Rail, river	+237	2,471
Utah	2,174	0	0	0	Rail	-3	2,174
Wisconsin	1,500	0	10	0	Rail, Great Lakes	-95	1,510
Wyoming	0	0	145	0	Truck	-15	145
TOTAL DOMESTIC	30,755	0	2,908	235		+1,476	33,898
Japan	843	0	unk	0			843
TOTAL DOMESTIC/ FOREIGN EXPORT	31,598	0	2,908	235			34,741

tons of Colorado coal. The station receives most of its fuel from Trapper and Colowyo mines, and a minor amount from Foidel Creek Mine. Nationally, Tri-State ranks 47th for coal consumption with its three coal-fired power plants in Colorado and New Mexico.

Xcel Energy recently reported estimating needs for more than 3,000 megawatts of electrical capacity in Colorado by 2013. Their customer's needs in this state have grown by 20 percent in the last ten years. Xcel currently produces over 1,500 megawatts of power in Colorado but must increase local power to meet future needs. They are currently exploring generating technologies including coal, gas, wind, and conservation needs. Much of their emphasis is on new coal technology. Plans for a new coal-fired power plant are still a serious consideration as a low-cost alternative. Xcel plans to file with the Public Utilities Commission in April 2004 a plan for a new coal fired power plant near Pueblo. The new power plant would be a $1.3 billion, 750-megawatt plant, built as an expansion to their Comanche Generating Station. This would more than double the station's capacity to 1,410 megawatts by 2009. Demand is so great that Xcel Energy chairman and chief executive Wayne Brunetti said that it might take two coal-fired generation plants and another large wind farm to meet the need. Nationally, coal represents about 52 percent of electrical power generation, but in Colorado it is about 84 percent.

Alternative power for electrical generating capacity has sputtered recently. A tax credit of 1.8 cents per kilowatt-hour for wind energy and biomass expired on December 31, 2003. At the State level, a bill to promote renewable energy standards is not moving forward. At the Federal level, the Energy Bill, which re-instates tax credits for renewables as well as geothermal, solar, and municipal waste is slowed by legislative backlog. According to the *Denver Post* (March 5, 2004), a Platts Research & Consulting report says Colorado's total power generation from renewable sources such as solar, wind and biomass is likely to fall to 2.7 percent in 10 years. It is currently at about 3

Table 11. Coal consumption at electric generation plants in Colorado, 2003.

MAP NO.	POWER PLANT	UTILITY	LOCATION	2003 COAL CONSUMP-TION	AMT. OF COLO COAL BURNED AT COLO P.PLANTS	CHANGE FROM 2002	PERCENT OF BTU BURNED AS COAL (2001 DATA)	AVG. BTU	AVG. SULFUR PERCENT BY WEIGHT	ORIGIN OF COAL
1	Drake	Colorado Springs Utilities	Colorado Springs	992,680	694,876	up	—-	10,521	0.46	70% Foidel Creek, 30% Wyoming PRB
2	Nixon	Colorado Springs Utilities	Fountain	995,133		up	—-	9,163	0.27	Wyoming PRB
3	Arapahoe	Xcel Energy (partly gas)	Denver	599,129		down	91	8,763	0.29	Wyoming PRB
4	Cameo	Xcel Energy	Palisade	315,733	315,733	up	99	11,081	0.48	McClane Canyon Mine
5	Cherokee	Xcel Energy	Denver	2,097,595	2,097,595	up	96	11,337	0.49	99 % Foidel Creek Mine, 1% Colowyo Mine
6	Comanche	Xcel Energy	Pueblo	2,927,760		up	100	8,598	0.32	Wyoming PRB
7	Hayden	Xcel Energy/Pacifcorp/ Salt River Project	Hayden	1,689,530	1,689,530	down	100	10,386	0.42	99% Seneca Mines, 1% Foidel Creek
8	Pawnee	Xcel Energy	Pawnee/Brush	2,432,894		up	100	8,412	0.36	Wyoming PRB
9	Valmont	Xcel Energy	Boulder	614,964	614,964	up	98	10,842	0.41	73% Foidel Creek, 27% Colowyo
10	Rawhide	Platte River Power Auth.	Wellington	1,295,094		up	99	8,832	0.23	Wyoming PRB
11	Craig	Tri-State G & T Assn.	Craig	4,785,824	4,785,824	down	100	10,181	0.38	58% Colowyo Mine, 39% Trapper Mine, 3% Foidel Creek Mine
12	Nucla	Tri-State G & T Assn.	Nucla	358,824	358,824	down	99	10,666	0.97	New Horizon Mine
13	W.N. Clark	Aquila Inc.	Canon City	151,406	151,406	down	99	—-	—-	Foidel Creek Mine
STATE TOTALS				**18,263,886**	**10,708,752**					

PRB = Powder River Basin / See Figure 26 for plant locations / Data collected from individual power plants

percent. Aquila, Inc. would like to implement a biomass burning project at their W. N. Clark plant in Canon City. The plant would burn wood and biomass waste as part of a U.S. Forest Service Green Tag renewable energy project. A 300 ton pilot project was successful in 2003, and Aquila hopes to be certified to burn more. At a maximum, it could reduce waste products up to 5 percent at the Clark Plant.

The high cost of natural gas at electrical generating plants is pushing power companies toward greater reliance on new coal and wind-power generation projects. The Colorado Green Wind Project was recently built near Lamar at a cost of $212 million. Owned by PPM Energy and Shell WindEnergy, it has a 162-megawatt maximum capacity (full wind), and will supply Xcel Energy contract customers. It is the nation's fifth largest wind farm. Reliability of wind is always a concern, and to keep base-load operations going coal-fired power will always be needed to assist these wind farms.

Employment and Productivity

Coal is the biggest component of Colorado's mining industry. 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. Gunnison County has the most miners employed with 550 in December 2003 (Fig. 25). Much of this is due to Oxbow Mineral's Sanborn Creek Mine maximizing coal production at the end of its mine life, and simultaneously working to open the new Elk Creek Mine in Somerset.

In terms of worker productivity Colorado's coal miners produce more coal per man-hour than most other states. In 2002, the average production per employee per hour was 8.29 short tons, down slightly from the 8.43 short tons of coal per miner-hour reported in 2001 (EIA 2002 data *http://www.eia.doe.gov/ cneaf/coal/ page/acr/acr.pdf*). However, in terms of the type of mining, underground miners (continuous and longwall mining methods) in Colorado

produced at a rate of 8.81 short tons per miner-hour, the highest in the nation. This was a three percent increase over 2001. Colorado surface mining productivity was 7.2 short tons per miner-hour, an eleven percent decrease over 2001. This was primarily due to surface mines not producing at the record levels of 2002. With the number of miners decreasing and the amount of coal production increasing in 2003 one can only expect these productivity numbers to increase for EIA's 2003 data. Safety is not being compromised in the increased productivity either.

Figure 27. Coal Miners Memorial, Trinidad, Colorado.

The U.S. Department of Labor's Mine Safety and Health Administration (MSHA) reports that 2003 was a year for the least amount of mining fatalities nationally since the coal industry began. In Colorado coal mines no fatalities occurred in 2003.

The 2003 Longwall Census from *CoalAge* magazine reports five active longwall machines in Colorado (Table 12). These are at Mountain Coal's West Elk Mine, Blue Mountain Energy's Deserado Mine, Bowie Resources' Bowie No. 2 Mine, Oxbow Mining's Sanborn Creek–Elk Creek Mines, and RAG American's Foidel Creek Mine. Colorado longwall faces are much larger than the average longwall face. Coal mining has come a long way from its pick and shovel operations from 100 years ago (Fig. 27). In terms of worker productivity, EIA reports that Colorado's longwall miners were the most productive in the nation for 2002, producing 9.53 short tons per employee per hour (EIA 2002 data most recent available). *http://www. eia.doe.gov/cneaf/coal/page/acr/acr.pdf*

Coal Quality and Reserves

There are four basic types of coal: anthracite, bituminous, subbituminous, and lignite. These coal rankings are differentiated based on physical characteristics such as hardness, density, heat value, and luster. Anthracite represents the hardest coal with the highest heat values and luster or vitrinite properties. It has heat values that range in the 12,000–14,000 Btu category. Lignite is at the other end of the

Table 12. Longwall miner operations in Colorado, 2003 (*CoalAge*, Feb. 2004).

REGION AND YEAR	SEAM	SEAM HEIGHT (in)	CUTTING HEIGHT (in)	PANEL WIDTH (ft)	PANEL LENGTH (ft)	OVERBURDEN (ft)	DEPTH OF CUT (in)	SHEARER
Bowie Resources (Bowie Mine No. 2)	D	108–180	120	845	7,000	800–1,400	36	DBT America DDR 1300
Blue Mtn. Energy (Deserado)	B	84–180	132	800	6,000	240–1,800	32	Joy 4LS-5 DDR 1030
Oxbow Mining (Sanborn Creek)	D	108–180	132	805	7,200	300–1,600	30	Joy 7LS-3A DDR 1700
RAG American Coal (Foidel Creek)	Wadge	96–114	96–114	1,000	12,000–15,000	600–1,400	36	DBT America DDR 1920
Arch-Mtn. Coal Company (West Elk)	B	276	144	950	3,500–9,000	1,400–2,200	40	Joy 6LS-2 DDR 1720

spectrum: less dense, dull luster, with Btu values less than 7,000 Btu. Colorado coal ranges throughout this spectrum, but is mainly bituminous and sub-bituminous. These resources are the main mineable coal for electrical-generating needs. Northwest Colorado has both bituminous and subbituminous coal. The Somerset area has bituminous coal with the only anthracite in the nearby Crested Butte area. The Denver Basin contains subbituminous and lignite resources.

Colorado coal quality is some of the most environmentally compliant in the nation (Table 13). Colorado is second only to Illinois in bituminous coal reserves, but is by far the leader in bituminous compliance coal reserves. Colorado coal produced in 2003 ranges between 0.4 and 0.8 percent sulfur. The average quality of coal received at electric utilities in Colorado is compliant with Clean Air Act standards. According to EIA, for 2001, the average quality of Colorado coal burned nationally at power plants was 11,068 Btu, 0.45 percent (by weight) sulfur, and 8.46 percent (by weight) ash. The average quality of coal received at manufacturing and coke plants in Colorado for 2001 was 10,853 Btu, 0.71 percent sulfur, and 8.33 percent ash (EIA 2001 data). Holcim U.S., a cement manufacturer, is the largest "manufacturing" consumer of coal in Colorado, and the eighth largest consumer of manufacturing coal in the nation. Of the other major manufacturing consumers of coal Southdown, Inc. is the largest in Colorado.

About 75 percent of Colorado coal leases are federally owned. Nearly 50,000 acres are currently under lease. For 2002 (most recent data), EIA reported that Colorado had 629 million short tons of recoverable coal reserves under lease, a significant increase over 2001. In terms of mining recovery, the average percentage of coal recovered at Colorado coal mines is 75.55 percent *http://www. eia.doe.gov/ cneaf/coal/ page/acr/ table15.html*). For underground mines, the average recovery percentage was 68 percent; for surface mines it was 89.28 percent.

The EIA's Demonstrated Reserve Base (DRB) data show Colorado with 16.5 billion short tons of coal; 11.72 billion short tons underground mineable and 4.77 billion short tons surface mineable (2002 data). In terms of sulfur content, approximately one-third of this reserve is less than 0.40 lbs. of sulfur per million Btu; 90 percent of Colorado coal reserves are less than 0.83 lbs. of sulfur per million Btu. The future trend is to mine significantly more coal in both northwest Colorado and the Somerset Coal Field, as these areas provide ample sources for low-sulfur, high-Btu coal. As long as there are power plants without scrubbers and sophisticated air-pollution control equipment, there will be a need for clean Colorado coal.

One of the more important topics in the eastern U.S. recently is the depletion of quality coal reserves. Thick seams of environmentally favorable coal quality in Central Appalachia, the Illinois Basin, and are becoming more difficult to mine. If thin-seam longwall mining becomes a reality through advancements in technology, then eastern coal will become more feasible.

Table 13. Average quality of coal burned at power plants nationally, by state of coal origin, 2001 (EIA data, 2001).

STATE	BTU PER POUND	SULFUR PERCENT BY WEIGHT	ASH PERCENT BY WEIGHT
Wyoming	8,689	0.32	5.29
West Virginia	12,190	1.16	12.58
Kentucky	12,166	1.48	11.02
Pennsylvania	12,961	1.79	8.16
Texas	6,405	1.13	16.62
Colorado	11,068	0.45	8.46
Montana	9,099	0.49	6.27
Indiana	11,077	2.12	9.03
North Dakota	6,537	0.74	9.63
Virginia	12,750	0.94	10.58

Colorado Coal News 2003

For 2003, higher than normal prices and stable marketplaces enabled increased high production for the fourth year in a row. No serious delays, accidents, or problems occurred to disable production. In terms of economic productivity, the 12 coal mines in the state all produced at or near capacity.

Northwest Colorado Coal Mining News

Twentymile–Foidel Creek Mine in Routt County produced 8,127,386 million short tons of coal in 2003, the largest Colorado coal mine. EIA lists Foidel Creek Mine as the 21st largest mine in the nation in terms of annual coal production. In addition, Foidel Creek is the fourth largest underground mine in the country (EIA Table 9, 2002 data). In December 2003, Peabody Energy announced that it signed a memorandum of understanding with RAG Coal International to purchase the Twentymile coal mine and a partial interest in some

Australian and Venezuelan coal properties. The transaction, as reported by the Denver Post on March 4, 2004, is for about $441 million. Peabody Energy is the world's largest private coal company with 2002 sales of 200 million short tons of coal valued at $2.7 billion. With the purchase of Twentymile, Peabody will account for nearly 10 percent of all U.S. electricity generation. Peabody currently owns the nearby Seneca II-W and Yoast surface mines in Routt County. Peabody has no major plans for personnel or equipment changes at this time.

The Seneca mines near Hayden (Yoast and Seneca II-W) produced less coal in 2003 than in 2002, due primarily to steepening coal seams. These two surface mines operated by Seneca Coal Co. and owned by Peabody Coal Co. mine the Wadge coal seam 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). They also take coal from the underlying Wolf Creek seam in a new pit area. About 10 percent was Wolf Creek coal, which averages 10,300 Btu. The mines are approaching overburden limitations on their high walls and must work with steeply dipping coal seams at times. Seneca may attempt high-wall mining beginning in April 2004. Future long-term plans are to continue servicing the Hayden Power Plant from an underground reserve southwest of Hayden when the surface tracts are depleted by 2011.

Trapper Mining Company reports that in 2003 the experiment with changing from dip-slope mining to strike-line mining was successful. The strike-line pits are up to 200 feet deep. In the Z-pit, Trapper is further along in five cuts. In the G-pit, the 200 feet box cut was successful. Cast-blasting and electronic programmable cast blasters help dampen vibration in the pit wall to stabilize high walls better. The higher stripping ratio will allow for less re-handle of material as they stair-step their way uphill (and up dip). In strike-line mining they will mine west to east and return for each major seam. The F-pit will remain dip-line. Shot patterns and cast-blasting must be re-adjusted for the new mining method to minimize overburden removal. Strike-line mining will add about 5 million short tons to the current reserve life. Recoverable reserves now are about 25 million short tons, or 12-year mine life.

The state's largest surface mine is Colowyo, in Moffat County, which produces coal from the Williams Fork Formation in the Danforth Hills Coal Field. In 2003 they produced just short of 5 million short tons of coal. Colowyo has 140 million short tons remaining of recoverable surface reserves on their property. In November 2003, the East Pit closed after 26 years of continuous operation. The final mining method there is a Highwall Miner, from Mining Technologies, Inc. The ADDCAR Highwall Mining System (Fig. 28) was contracted in January 2004 to mine coal remaining in thick seams at the base of the pit. The mid-seam miner has an 11.5-foot wide Joy Miner cutting head, similar to a conventional miner. It can advance about 1,100 feet on average per 10-hour shift. The cutting head is connected to a series of segmented conveyor flights that are

Figure 28. High Wall Miner at Colowyo Mine, Moffat County. Photo courtesy of Kennecott Corp.

assembled as mining progresses. According to Juan Garcia, Colowyo's engineer in charge of the Highwall operation, this is the first Highwall miner ever used in Colorado. It produces about 550 to 600 short tons of coal per hour. Designed with web-pillar spacing, the pillars are spaced about 7 feet apart. The key to not caving is to punch an 1,100-foot hole in about 10 hours and withdraw. It is designed to have zero subsidence because there are no crosscuts for roof failure. The operators started with the lowest seam, the E seam, and then mine the D, C, and B seams in higher fashion. This system recovers significantly more coal in a surface operation than would otherwise not be achieved. The surface pits are very deep now (over 500 feet) and Colowyo wanted to determine the feasibility of underground mining the remaining permitted reserve. The Highwall Miner drills up-dip at about 4 degrees, but can go up to 10 degrees. This is the limiting factor to depth of mining.

Figure 29. Xcel Energy's Cameo Power Station, near Palisade, Colorado.

The McClane Canyon Mine in Garfield County, previously owned by Lodestar, was sold to Central Appalachian Mining (CAM) from Pikeville, Kentucky on May 19, 2003. The mine continues to produce about 300,000 short tons annually to supply the Cameo Power Plant (Fig. 29) near Palisade, Colorado. CAM also participated in a Bureau of Land Management Federal lease sale in January 2004. CAM won the competitive bid for the Spink Canyon Tract north of Loma, Colorado. This location is just west of the McClane Canyon Mine in Spink Canyon on 1,520 acres with an estimated recoverable reserve of 8.36 short tons of 10,700 Btu coal. The company will move west from its current position. The McClane Canyon Mine is experiencing some seam splitting and thinning coal beds to the east and prefers the western reserve, as the stratigraphic sequences for coal bed formation are thicker and less faulted in the new lease area.

The Deserado Mine in Rio Blanco County near Rangely produced 2,008,876 short tons of bituminous Mesaverde Group coal. 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. The private train line is unique in that it is the only privately run electrically powered train in the U.S. During 2003 the underground mine encountered a claystone channel deposited within the coal bed, which split it for about 100 feet along the longwall panel. The mine had no choice but to remove the channel while mining. The wash plant cleaned up the parting but coal deliveries were down slightly in May 2003. It took two months to cut through the clay–bentonite layer before accessing good coal again. Deserado is currently mining the B-seam in the western part of the mine. They are now in the fifth longwall panel of the B-seam. Gate road development of the 13,000 foot long sixth panel is currently underway.

Somerset Coal Field News

Oxbow Mining closed the underground Sanborn Creek Mine in February 2003. Personnel there were quite pleased to retreat from the mine without serious injury. Sanborn Creek was over 2,000 feet deep with frequent rock bursts and floor heaving conditions and methane gas problems. Sanborn Creek mined nearly 500,000 short tons of coal in 2003, taking its eleven-year production life total to over 17.4 million short tons of high-Btu (12,300 Btu average), low-sulfur (0.5 percent) bituminous coal. The company then conducted a two-month move to the nearby Elk Creek Tract. The new mine allows Oxbow to mine larger longwall panels. Mining conditions are much improved, as the Elk Creek Mine has no gas problems with only 700 feet of overburden. They are mining the D seam, which is 200 feet above the B seam. Four of the first six years of operation will be mining less than 1,400 feet of overburden. Methane gas levels currently are low and desorption levels in the D-seam by cores drilled by Raven Ridge for Gunnison Energy are considerably lower in the D seam, as compared to those encountered at Sanborn Creek in the B-seam. They are in the first panel with coal quality values at about 12,100 Btu, 0.42 percent sulfur, and 7–8 percent ash.

The West Elk Mine on the east end of the North Fork Valley in Somerset had another excellent year (Fig. 30). Coal sales were up and production was again over 6 million short tons in 2003. West Elk mines coal in the B-seam of the Mesaverde Group. The B-seam is one of the nation's top-producing coal seams with an average thickness of 161 inches (EIA 2002 data). West Elk has been operating since 1992 and produced over 60 million short tons of coal over that time. Previous to 1992, the mine was called the Mt. Gunnison Mine, which produced about 5 million short tons of coal between 1981 and 1991. Currently West Elk is mining in the northeastern section of their C-1362 lease. They filed for a new exploration license to drill in 2005.

West Elk Mine was selected by the U.S. Geological Survey as the best national reserve to model high-volatile bituminous coal with low trace element chemistry. As a national standard, they sampled stockpiled coal at West Elk in May 2003. Results of testing show that the average run-of-mine samples average 3.5 percent moisture, 7.2 percent ash, 0.66 percent sulfur; trace elements of significance include 0.054 ppm mercury, and 121 ppm chlorine. They sell 11,900 Btu coal. West Elk is currently doing a test burn in the Boston, Massachusetts area now for compliance coal purposes. The coal was shipped through the Great Lakes region by barge and railed elsewhere. A contract there would be the longest domestic coal supply from Colorado.

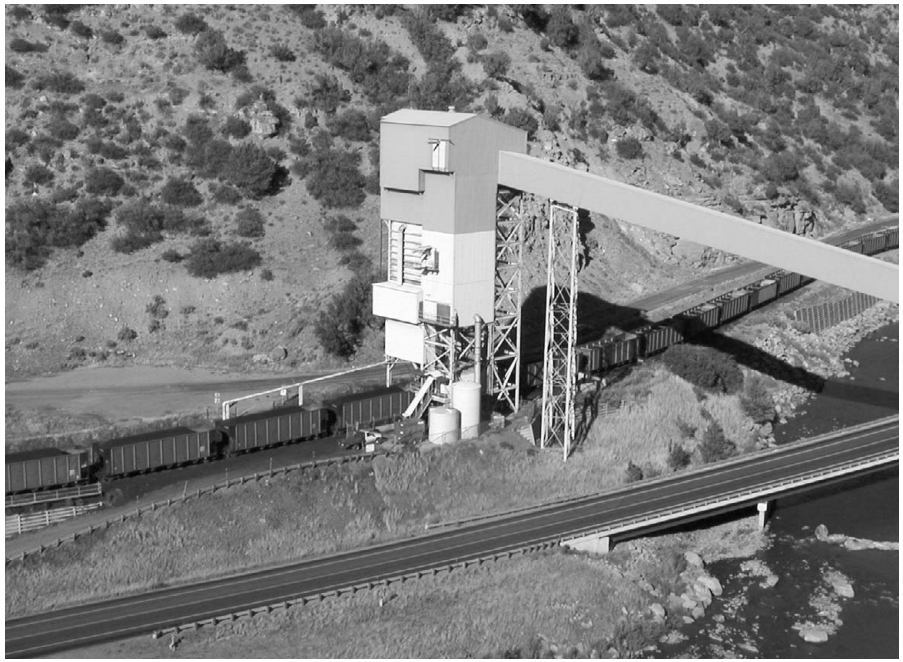


Figure 30. West Elk Mine load-out. Photo courtesy of Mountain Coal Company.

Bowie Resources near Paonia produced slightly less than 5 million short tons of coal in 2003. Bowie Mine No.2 is operating a longwall operation in the Mesaverde Group D-seam. They have mined most of the coal in the present panel area, as the reserve life is less than anticipated. Bowie started excavation work (Fig. 31) in August 2003 to mine the B-seam. They started a box cut for the three portals for the B-seam. This access is located on their road just beneath the field office, and plans are for this mine to become the Bowie No. 3 Mine. Conventional production began in January 2004 to remove coal during development of the gateway haulage roads, and in February 2004 they actually produced 3,000 short tons of coal. In addition to the new mine, Bowie is also constructing a new prep plant for the B-seam. It is a heavy media type cyclone plant, scheduled for operation by May 2004. This will assist with the high ash problem they anticipate. The Bowie No. 2 Mine will continue to operate in the D-seam until about March 2005.

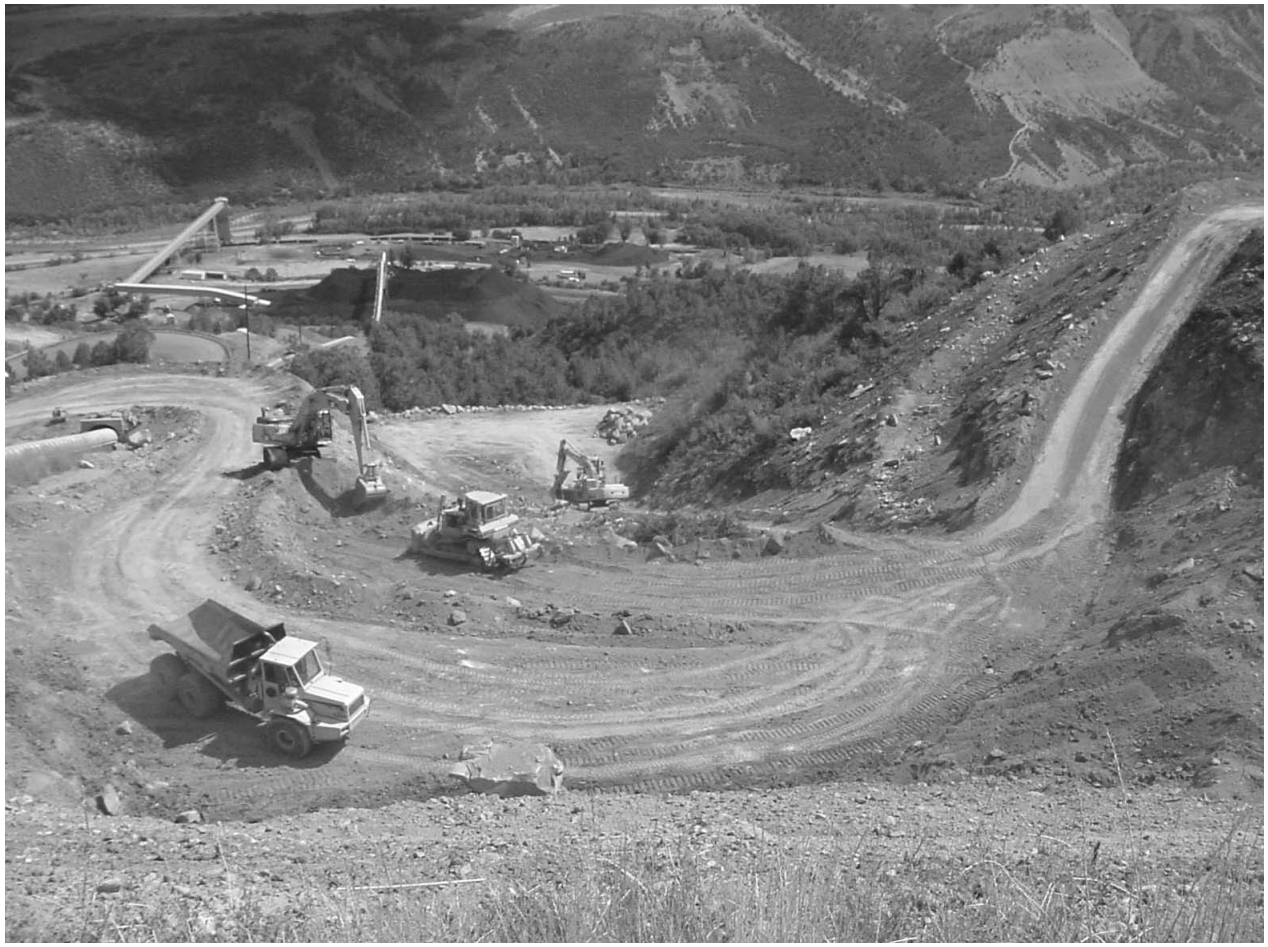


Figure 31. Excavation work on the new B-seam portal beneath the Bowie No. 2 Mine, near Paonia, Colorado, August 2003. Photo courtesy of Bowie Resources.

Other Colorado Coal Mining News

National King Coal's mine near Durango set new coal production records in 2003. King Coal reported 392,966 short tons produced in 2003, a new record for the 68-year old mine. In October 2003 they produced 45,445 short tons, an all-time monthly record. Spot sales of coal to cement plants picked up in the last part of 2003. The high Btu and the low ash mixture make for very good cement manufacturing. The existing mining operation should still be viable for the next five years and possibly up to 12 years depending on development drilling results. Coal quality is very consistent at 12,500 Btu. King Coal is Colorado's oldest and longest continually operating coal mine.

The Colorado Geological Survey is currently compiling a stratigraphic database of drill hole data for coal resources in the Raton Mesa Coal Field (Fig. 32) near Trinidad. Although Lorencito Canyon, the only recently operating mine in that region has closed, the potential still exists for coal mining in the future. Currently, the basin is a coal bed methane production area, with over 1,800 wells drilled in the last five years. Stratigraphic data available from those wells is used to calculate remaining coal beds and resources for this area. Although 262 million short tons of coal has been mined in the area, potentially 13 billion tons of coal remains. Much of this is thin-seamed, however. Yet enough thick coal remains for the coal bed methane producers, and when they are finished, coal mining may return to the area.

At the Colorado Mining Association's 106th National Western Mining Conference in February 2004, several Colorado coal companies and contractors won awards. Trapper Mine won the top Colorado Division of Minerals and Geology (DMG) reclamation award for "Excellence in Reclamation and Outreach" for achieving Phase III bond release on 1,857 acres of reclaimed surface mining, and for their commitment to the local community of Craig, Colorado. Also winning DMG reclamation awards were Energy Fuels Co. for reclamation of the Southfield Mine for the small underground mine award. Bowie Resources won the large underground mining award for their reclamation of the Bowie No.1 Mine. Kennecott Energy and Colowyo won an award for steep-slope reclamation as well. Final bond release reclamation awards went to Sunland Mining Corp and Greg Lewicki and Associates for their work on the Apex No. 2 Mine final bond release success. Minrec, Inc., and J.E. Stover and Associates won an award

Figure 32. Igneous dikes can be seen crosscutting coal seams and sandstones in the Raton Mesa Coal Region.

for partial Phase III Bond release at the North Thompson Creek Mines. Safety awards were given to Blue Mountain Energy and the Deserado Mine for the large underground coal mine in reducing its lost-time accident rate from 12.37 in 1997 to 3.80 in 2003. Bowie Resources won a similar award for their Bowie Mine No. 2. Kennecott Energy and the Colowyo Mine won the large surface coal mine award for reducing lost-time injury rate from 1.47 in 2001 to 0.26 in 2003.

2004 Coal Future

According to Steve Fiscor, editor in chief of *CoalAge*, the national forecast for 2004 is one of higher coal prices. Most experts believe that the coal industry is poised for improved profitability in the near future. *CoalAge* feels that production will be up significantly in 2004, predicting a 5 to 8 percent increase. In Colorado that has already commenced and as of March 2004 the state's coal industry is poised to produce over 40 million tons for the year. Colorado's coal industry is reaching a capacity maximum with the recent increased demand. To increase capacity more mines must open and new transportation routes must open to increase production beyond the current rate. Otherwise the twelve existing mines will be able to supply a stable coal product of about 40 million tons per year of compliance coal to meet the nation's energy needs.

INTRODUCTION

By John W. Keller and Beth Widmann

Nonfuel mineral production in Colorado includes metals, industrial minerals, and construction materials such as sand and gravel. In 2003, the total value of nonfuel mineral production in Colorado is estimated at $702 million. This is an 11.6 percent increase over the 2002 estimated production value of $629 million. Colorado ranked 22nd among the 50 states in production of nonfuel minerals in 2003 (Table 14). In 2002, Colorado was ranked 23rd in the U.S. for nonfuel minerals. Much of the mineral production data presented here is obtained from the Minerals Information group of the U.S. Geological Survey, which can be accessed at *http://minerals.usgs.gov/minerals/*. The estimated total value is based on a combination of estimates by the U.S. Geological Survey and the Colorado Geological Survey. The increase in value is mainly due to increased production of gold, molybdenum, and soda ash. Significant price increases for gold and molybdenum also contributed to the higher production value. Figure 33 shows the value of nonfuel mineral production in Colorado and the percent of the total value of each commodity type. Figure 34 is a map of selected industrial mineral and metal mines in the state and some of the exploration and development projects in 2003. Table 15 lists the mines and prospects, their owners, mine type, and commodity.

Figure 33. Colorado nonfuel mineral production value, 2003.

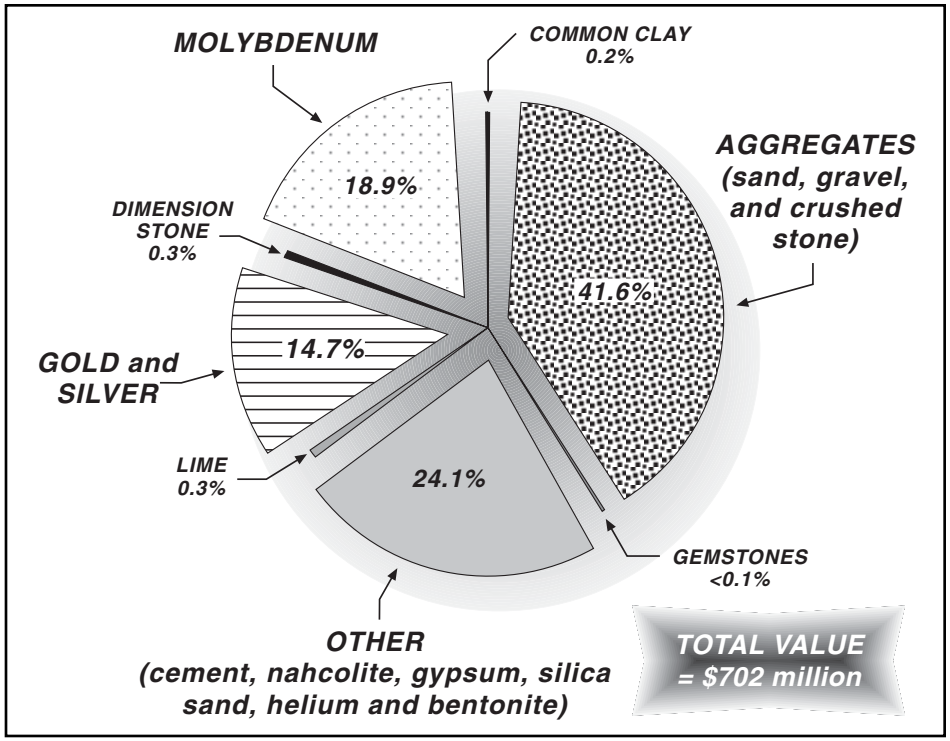


Table 14. Colorado's ranking among the 50 states for the production of selected mineral resources.

COMMODITY	2000 RANKING	2001 RANKING	2002 RANKING	2003 RANKING
Total nonfuel mineral production value	25	26	23	22
Molybdenum	3	2	2	NA
Gold	8	7	5	NA
Construction sand and gravel	6	9	8	10
Coal	10	10	8	7
Oil	11	11	11	NA
Natural gas	6	6	6	NA

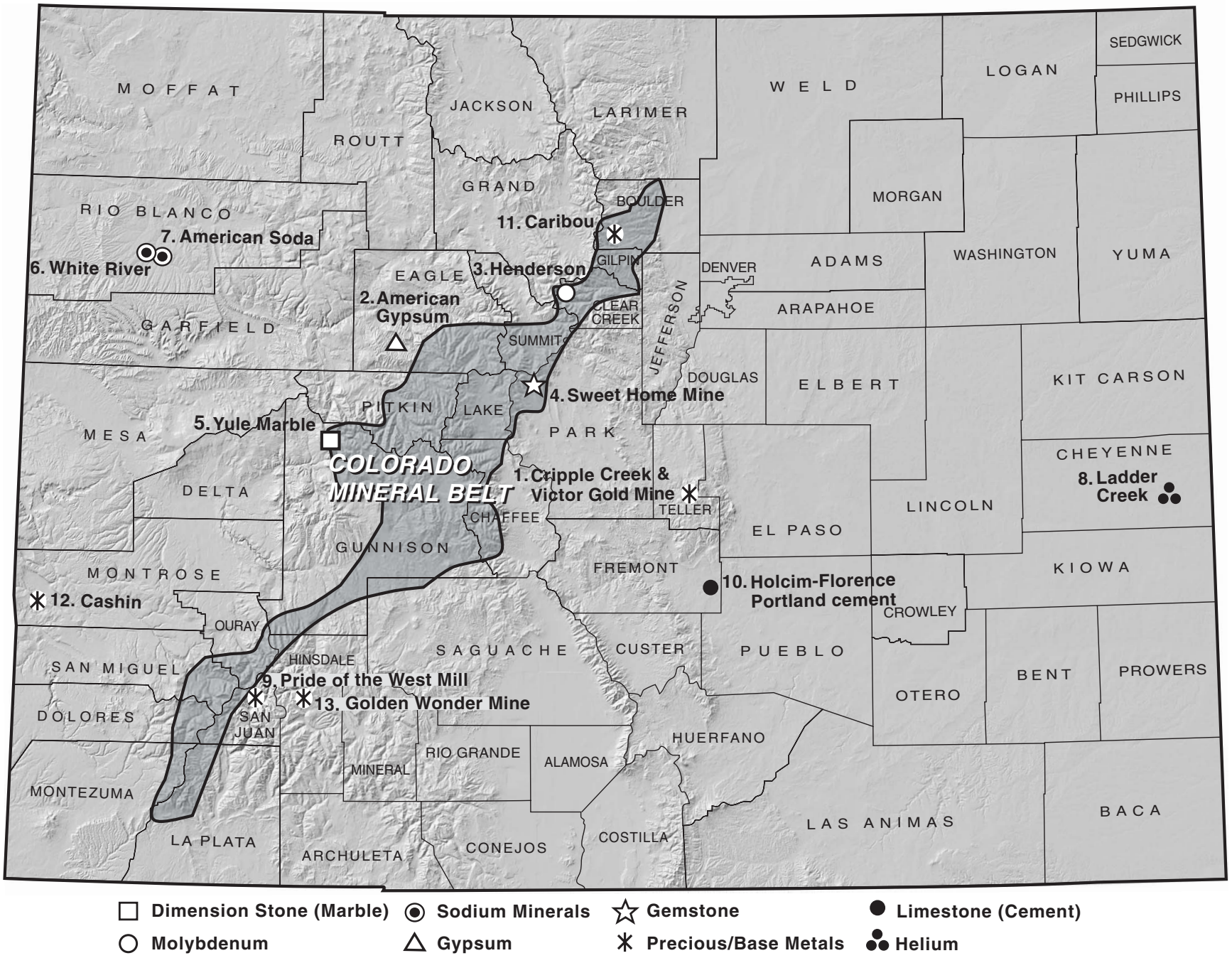


Figure 40. Map of major metal and industrial minerals mines and prospects in Colorado (does not include sand, gravel, or crushed stone operations).

Table 15. Top producers and prospects of nonfuel minerals in Colorado. Numbers refer to map in Figure 36. (Excludes sand, gravel, and crushed stone operations).

MAP NO.	MINE OR PROJECT	COMMODITY	MINE TYPE	OPERATOR
1	Cripple Creek & Victor Mine	gold, silver	OP	Cripple Creek & Victor Gold Mining Co. (AngloGold)
2	American Gypsum	gypsum	OP	Centex Construction Products, Inc.
3	Henderson	molybdenum	UG	Phelps Dodge Corp.
4	Sweet Home	rhodochrosite (specimen)	UG	Sweet Home Rhodo, Inc.
5	Yule Quarry	marble	UG	Sierra Minerals Corp.
6	White River	sodium bicarbonate	SOL	Natural Soda, Inc.
7	American Soda	soda ash and sodium bicarbonate	SOL	American Soda LLC
8	Ladder Creek Plant	helium	P	Duke Energy Field Services
9	Pride of the West Mill	gold, silver, base metals	P	Silver Wing Co., Inc.
10	Portland	limestone/cement	OP/P	Holcim, Inc.
11	Caribou Consolidated district	gold, silver	EX	Calais Resources, Inc.
12	Cashin	copper	EX	Constellation Copper Corp.
13	Golden Wonder Mine	gold	UG	LKA International Inc.

Abbreviations: UG—underground; OP—open pit; SOL—solution; P—processing plant; EX—exploration/development project

METAL MINING

The entire metal mining sector enjoyed rising commodity prices in 2003. In Colorado, the raw monetary value of metals mined rose sharply as both prices and production rose. Worldwide, the price increases have resulted in increased expenditures for exploration and development of metal deposits. More financial capital has become available to the industry for new projects. An October 2003 article in the *Denver Business Journal* announced that their annual Fastest Growing Public Companies list was nearly dominated by mineral companies. Of the 42 Colorado public companies that showed an increase in net income from 2000 to 2002, eight are mineral companies and five of the eight are gold companies. Two oil and gas companies and one coal company also made the list.

Precious and Base Metals

Cripple Creek & Victor Mine, Teller County

The Cripple Creek & Victor Gold Mining Co. (CC&V) continues to operate the only large precious metal mine in Colorado. The Cripple Creek & Victor Mine produced 283,868 ounces of gold in 2003, up 27 percent from the 224,000 ounces produced in 2002. The increase is due to the October 2002 completion of a major expansion and capital improvement project. The project included a fleet of nine 310-ton Euclid Hitachi EH 4500 haul trucks (Fig. 35), an expanded heap leach pad, construction of a new maintenance facility, a new crushing facility, and an expanded gold recovery plant. Figure 36 shows Colorado gold production and gold price from 1968 through 2003. Gold prices increased substantially in 2003, averaging $363 per ounce according to Kitco, Inc (data accessed at *http://www.kitco.com/scripts/hist_charts/yearly_graphs.cgi*). This is an 18 percent increase from the 2002 average gold price of $310 per ounce. The raw value of the gold produced at the mine in 2003 is approximately $103 million. In 2003, 142,212 ounces of silver were produced as a byproduct at the mine as well. However, the raw value of silver produced is less than one percent of the gold. The mine is again expecting to increase production in 2004 to an estimated 350,000 ounces of gold, as benefits and efficiencies of the expansion are fully realized. The reserve base at current prices is sufficient to support gold production until at least 2012.

In 2003, CC&V donated $100,000 toward the construction of a new regional medical facility for Cripple Creek. The company is also actively involved in historic preservation and trail system planning and construction in the area. CC&V is a joint venture between AngloGold and Golden Cycle Gold Corp. The mine currently employs approximately 300 people and is the largest private employer in Teller County.

Gold was originally discovered in the Cripple Creek district in 1891. Since then, the

Figure 35. The tire of one of several 310-ton capacity Euclid Hitachi EH 4500 trucks purchased by the Cripple Creek & Victor Mine for its $168 million expansion project, which was completed in the fourth quarter of 2002 (Colorado Geological Survey geologist, Beth Widmann, for scale).

district has produced about 23 million ounces of gold, easily making it the largest gold-producing area in Colorado history and the third largest in U.S. history. Early mining was from "bonanza" high-grade vein deposits. Present mining is done by open pit methods on low-grade, disseminated gold ore. Both the high-grade veins and the low-grade ore in the district are hosted by a mid-Tertiary alkalic volcanic and diatreme complex.

Pride of the West Mill, San Juan County

The Pride of the West Mill (Fig. 37) northeast of Silverton in San Juan County has been rehabilitated to process base and precious metal ore derived from historic mine waste piles in the Animas River watershed. The project is managed by the Silver Wing Co., Inc. of Silverton, Colorado. In February 2003, the project received final approval from the state to begin processing material. In August 2003, the mill began processing ore. Concentrates have been produced but have not been shipped yet. Extreme cold weather and a lack of insulating snow cover in November resulted in the mill "freezing up" and it was shut down for the rest of the winter. The mill will be running again by late March 2004. A significant stockpile of ore from old mine waste piles remains waiting to be processed.

Silver Wing Co. also owns a 90 percent interest in the Gold King Mine, which may eventually provide fresh ore to the mill. The mill, which has a capacity of 300 tons per day, uses differential flotation to produce lead, zinc, and copper concentrates. A gravity circuit is also present. Concentrates will be shipped to smelters out of state. A small carbon-in-pulp cyanide leach system scavenges gold from ore in enclosed agitation tanks at the end of the milling process. The cyanide in solution is then destroyed by hydrogen peroxide. Gold King Mines Corp. (a subsidiary of Silver Wing Co., Inc.) has acquired the American Tunnel Water

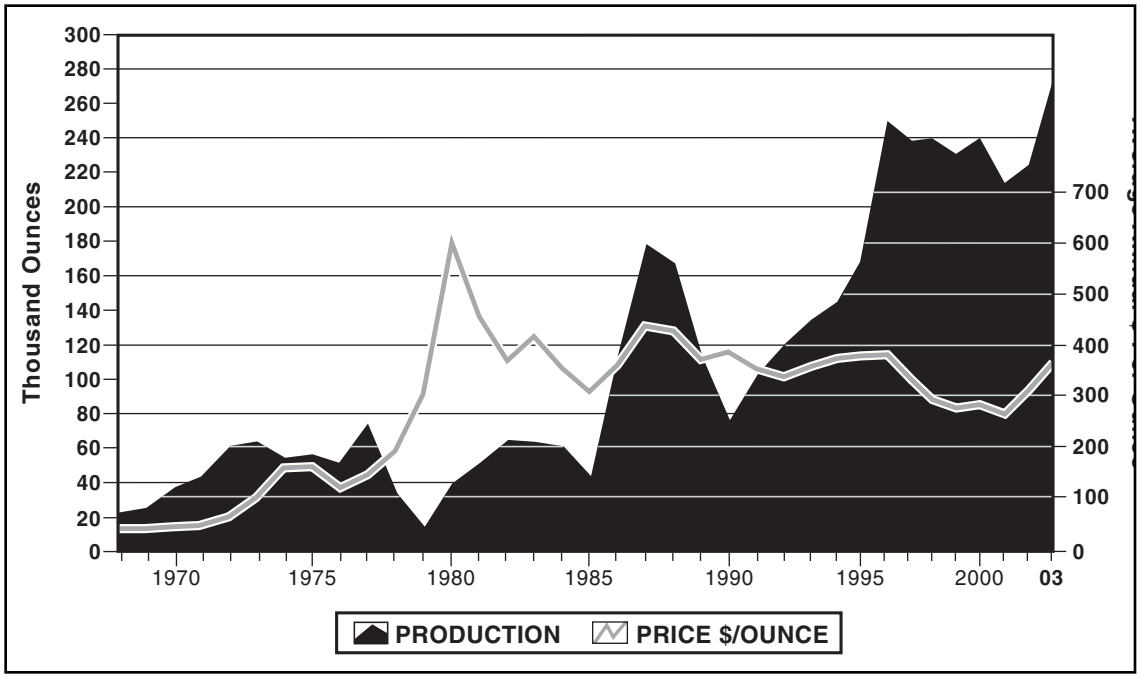


Figure 36. Colorado gold production and gold price, 1968—2003.

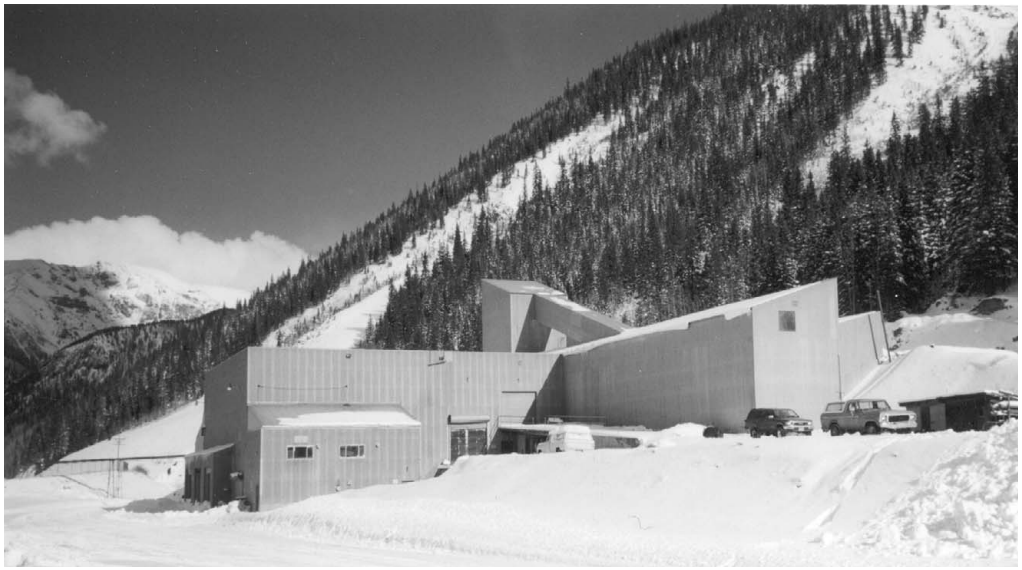


Figure 37. Pride of the West Mill near Silverton, San Juan County (Photo courtesy of Steve Fearn).

Treatment Plant at Gladstone. The water treatment plant is necessary to process mine water if and when the Gold King Mine begins operation. The Pride of the West project has strong support and assistance from the Animas River Stakeholders Group (Web site: *http://www.waterinfo.org/arsg/main.html*), a coalition of private, state, and federal interests that are working to clean up mine waste that contributes to the pollution of the Animas River.

Golden Wonder Mine, Hinsdale County

The Golden Wonder is a small, underground gold mine about two miles southeast of Lake City. High-grade gold ore is mined from epithermal quartz veins. The ore is trucked out of state in "super sacks" for milling and further processing. No quantitative information regarding production for this mine is publicly available.

Consolidated Caribou Project, Boulder County (Exploration and Development)

Calais Resources conducted exploration drilling at its Consolidated Caribou project in late 2003 (Fig. 38). The January 2004 issue of *The Mining Record* highlighted the results of the 3,635-foot core drilling program. Several previously untested gold-bearing veins that contain gold were encountered in the drilling. One 4.0-foot interval assayed 0.533 ounces of gold per ton. An ambitious exploration program is planned for 2004. Tom Hendricks, President and CEO of Calais Resources, said the company is expecting to commence a 65,000-foot core drilling campaign in April.

The Consolidated Caribou project is located within the northeast-trending Colorado Mineral Belt. Ore is hosted mainly by northeast-and east-west-striking quartz veins and breccia zones. Country rock consists of Proterozoic-age gneiss and granodiorite that have locally been cut by Tertiary-age intrusives, principally monzonite and quartz monzonite.

A study by Calais Resources in 1998 indicated combined resources of 1.4 million tons of ore containing 424,500 ounces of gold (0.30 ounces per ton) and 11.7 million ounces of silver (8.2 ounces per ton). There are also recoverable quantities of lead, zinc, and copper in the ore. Geological modeling that incorporates new drill data and updated interpretations of historic geologic data, using sophisticated 3-D modeling software, is continuing.

Cashin Copper Deposit, Montrose County (Exploration)

Constellation Copper Corp. conducted substantial exploratory drilling in 2003 on the Cashin copper deposit in extreme western Colorado (Fig. 39). Cashin is located only 15 miles northeast of Constellation's Lisbon Valley copper deposit in Grand County, Utah. The Lisbon Valley deposit is gearing up for production. The Cashin deposit is considered to be a "satellite" of the Lisbon Valley deposit and may eventually provide ore feed to the processing facilities at Lisbon Valley. Copper was originally discovered in the Cashin area in 1896, and was mined from 1899 to the mid-1900s. Historic mining in the Cashin area focused on high-grade deposits along steeply dipping, northeast-trending faults. Mineralization consists principally of the copper carbonates, malachite and azurite. Chalcocite, neoticite, and chrysocolla are also present. Native copper (and some native silver) were occasionally found in the high-grade parts of the historic mine. Copper mineralization at Cashin is hosted by the Wingate Sandstone of Triassic age.

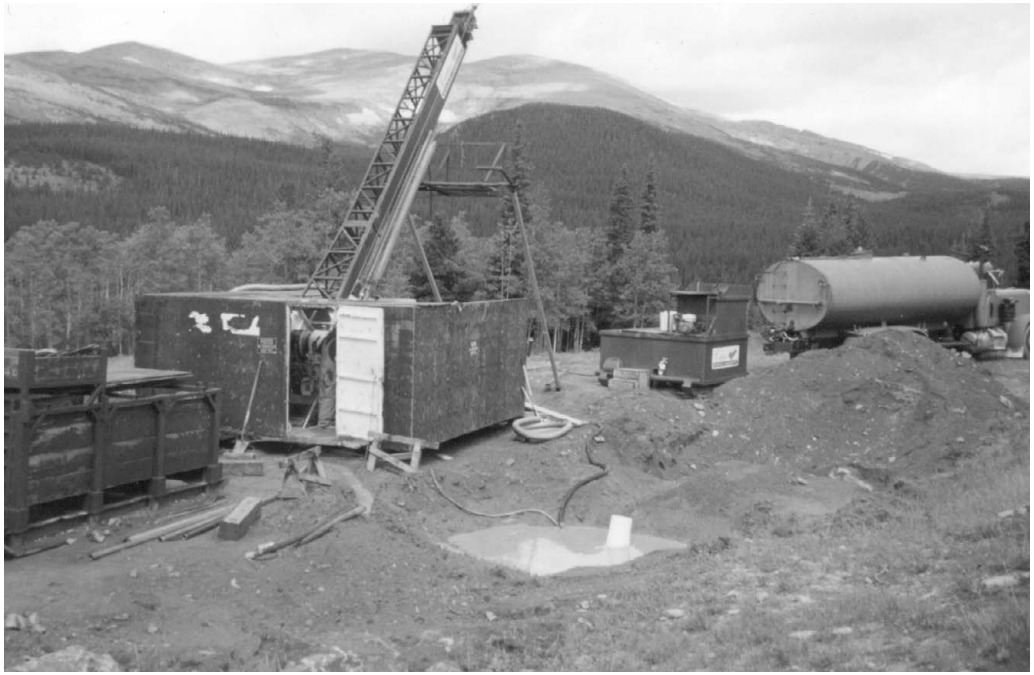


Figure 38. Longyear 44 core drilling rig at work in 2003 at the Consolidated Caribou project, Boulder County (photo courtesy of Tom Hendricks, Calais Resources Inc.).

approved a plan of mining operations for Midas Mining Co. (also known as Ophir-Nevada Mining Co.) to reopen the Ophir Lode, a historic gold, silver, and base metal mine in the Henson Creek mining district. The county stipulated that a maximum of six truckloads of ore per day could be transported out of the mine site via public roads. The trucks must be no larger than ten-wheel tandem dump trucks. When operational, the company expects this small-scale seasonal operation to produce about 7,000 tons of ore per year. The mined ore will not be processed at the mine site. The company received its mining permit from the Colorado Division of Minerals and Geology (DMG) in 2003. As of March 2004, mining had not yet begun at the site.

Based on previous drilling, a mineral inventory of approximately 13 million tons grading 0.5 percent copper (130 million pounds of copper) were estimated for Cashin prior to the 2003 exploration program. Much of the 2003 drilling targeted areas that had never previously been tested. Assay results released by Constellation suggest that the drilling was successful in delineating additional copper mineralization, as well as upgrading the resource that was partially defined by previous exploration. Assay results from a "true twin" of a 1960s drill hole suggests that the previous copper inventory may be underestimated by as much as 60 percent where the grade model is influenced by the older drill holes.

Figure 39. Exploration core drilling into a vertical cliff of Wingate Sandstone at the Cashin copper deposit, Montrose County, December 2003.

Ophir Lode, Hinsdale County

In early 2003, Hinsdale County Commissioners

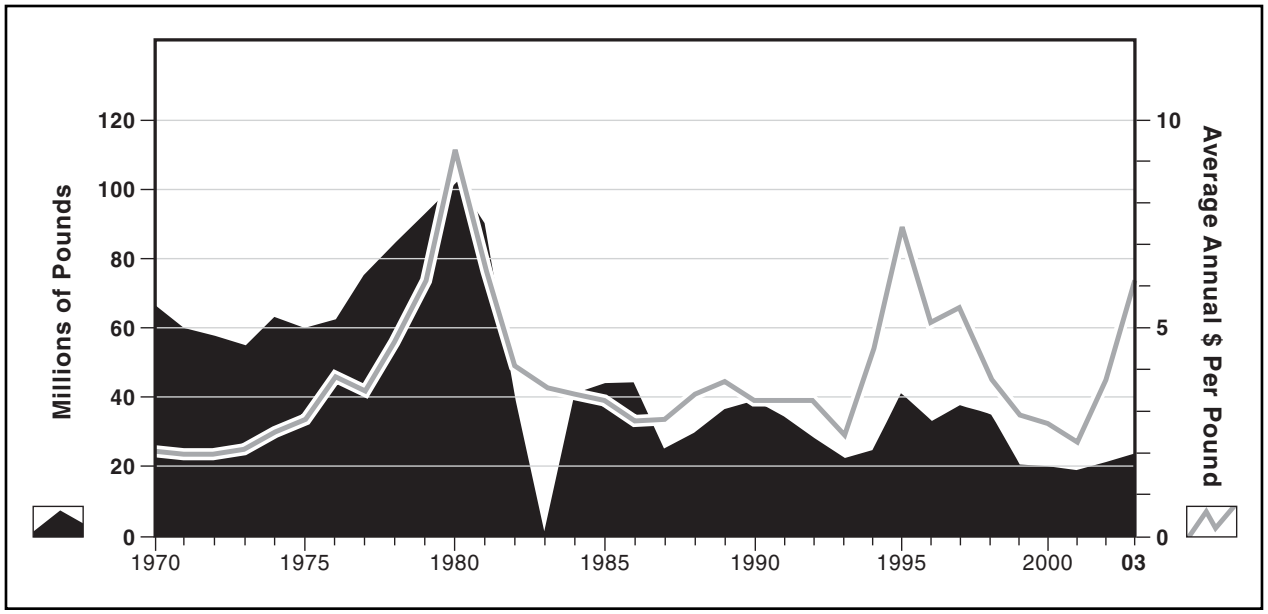


Figure 40. Molybdenum production in Colorado and average molybdenum prices, 1970—2003.

MOLYBDENUM

Henderson Mine, Clear Creek County

The Henderson Mine in Clear Creek County continues to be North America's largest primary producer of molybdenum. The underground mine is owned by Climax Molybdenum Company, a subsidiary of Phelps Dodge Corp. The operation employs about 320 workers at the mine and mill. In 2003, the mine and mill produced 21.7 million pounds of molybdenum metal contained in concentrates. That is a 6 percent increase from the 20.5 million pounds produced in 2002. In 2003 the estimated average price for molybdenum contained in technical-grade molybdic oxide was $6.12 per pound; up 63 percent from an average of $3.75 in 2002. Using the average price, the calculated value of molybdenum produced at the Henderson Mine in 2003 is estimated to be $133 million. Figure 40 shows molybdenum production in Colorado and average price per pound of molybdic oxide from 1970 through 2003.

The Henderson orebody is elliptical in shape and lies about 3,500 feet beneath the summit of Red Mountain. The orebody is estimated to contain 800 million tons of ore averaging 0.2 to 0.3 percent molybdenite. Molybdenite (molybdenum sulfide) occurs in stockwork veins and is relatively evenly distributed throughout the orebody. Ore is mined using the block caving method.

At the 2004 Colorado Mining Association Conference, the Henderson Mine won the Safety Award for Large Underground Metal Mines from the Colorado Division of Minerals and Geology for significant improvements in mine safety in 2003.

URANIUM AND VANADIUM

Uranium prices increased significantly in 2003, continuing a trend that has been going on for several years. The average price for uranium oxide was $14.50 per pound by the end of 2003. The average price during 2002 was only $9.90 per pound, and in 2001 it averaged $8.80 per pound. The steady price increase has encouraged some exploration and mine development activity.

JD-9 Mine, Montrose County

A small amount of uranium ore was mined in Montrose County in 2003. It is the first production of uranium ore in the state since the Schwartzwalder Mine in Jefferson County closed in early 2000. Cotter Corp. opened the JD-9 mine and produced approximately 3,000 tons of high-grade uranium ore. Four people are employed at the mine. Cotter is also looking into the possibility of opening another small uranium mine in the same area in southwestern Colorado.

INDUSTRIAL MINERALS AND CONSTRUCTION MATERIALS

The largest segment of the nonfuel mineral industry in Colorado continues to be sand, gravel, and crushed stone. Other important industrial minerals and construction materials currently being produced in Colorado include soda ash, sodium bicarbonate, cement, clay, gypsum, dimension stone, silica sand, and decorative stone.

SAND, GRAVEL, AND CRUSHED STONE (CONSTRUCTION AGGREGATE)

The main uses for sand and gravel are concrete aggregate, road base and coverings, construction fill, and asphaltic concrete aggregate. Crushed stone is used primarily as an aggregate for road construction and highway maintenance. Colorado produced nearly 55.8 million tons of aggregate in 2003 (Fig. 41) and ranked 10th in the nation for sand and gravel production. The total value of Colorado aggregate produced was $292 million. This is a decrease of 9 percent below the 2002 value of $319 million. Sand and gravel represent 66 percent of Colorado's total aggregate production, and while sand and gravel production totaled nearly 41 million tons, it was down 17 percent from last year's production. Similarly, crushed stone production decreased 9 percent. Average unit values of $5.00 and $5.81 per ton were calculated for sand and gravel and crushed stone, respectively (Fig. 42).

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 and escalating 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 exorbitant, and often prohibitive, amount of time and money (Fig. 43). Several counties in Colorado are not able to meet their aggregate needs independently (deficit counties) and must import aggregate from nearby counties with excess

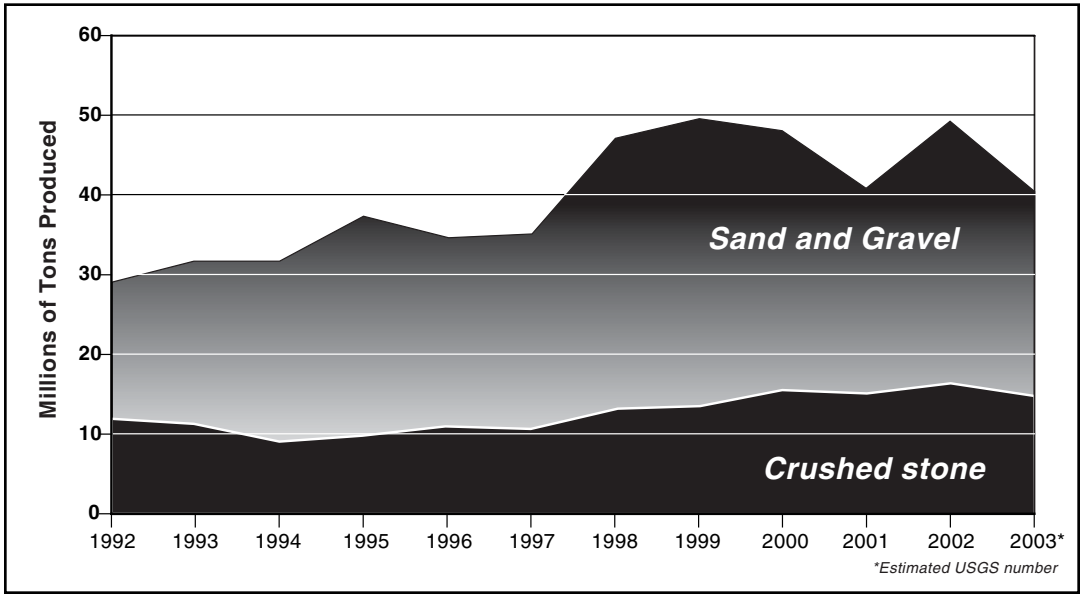


Figure 41. Production of sand and gravel vs. crushed stone in Colorado, 1992—2003.

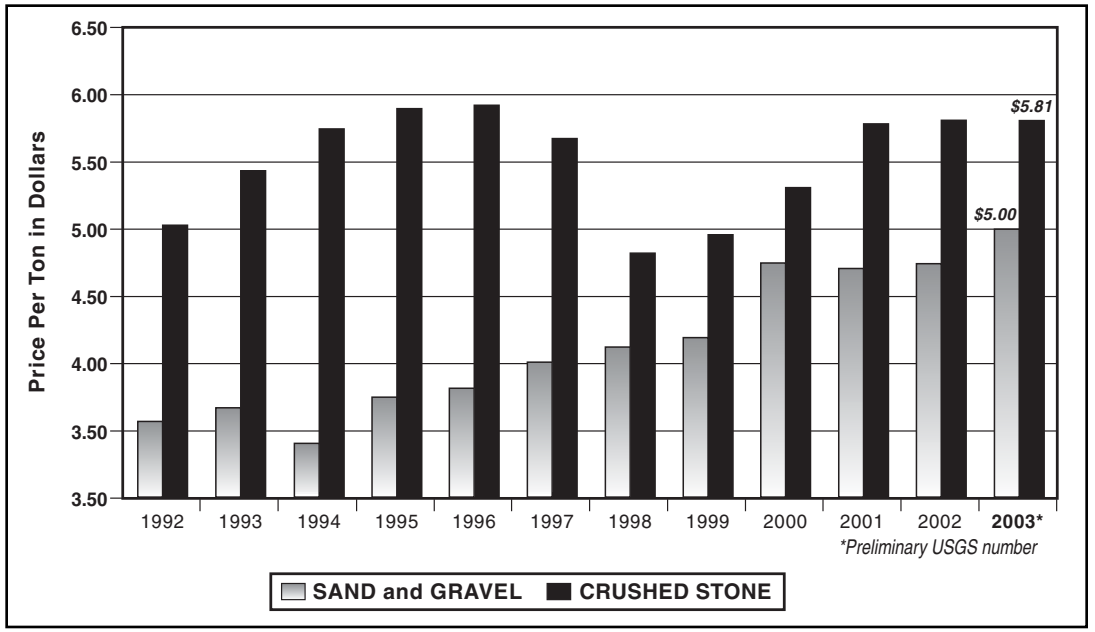


Figure 42. Average estimated price per ton of sand and gravel vs. crushed stone in Colorado, 1992—2003.

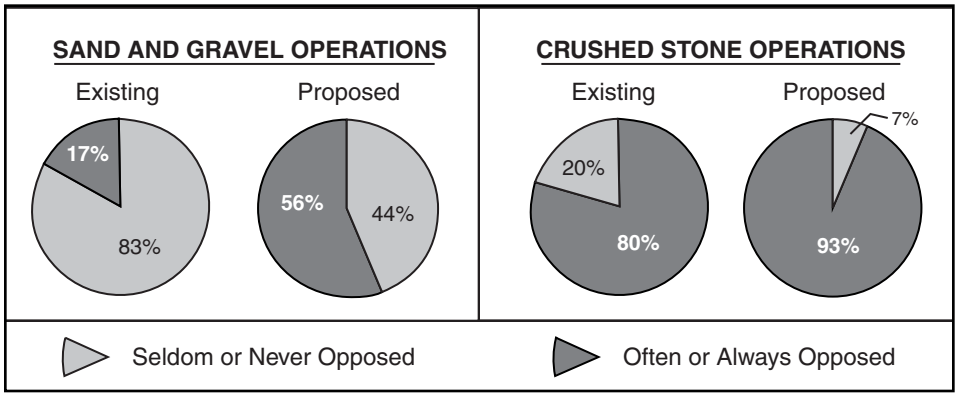


Figure 43. Opposition to existing and proposed sand and gravel or crushed stone operations based on a poll of county planners in several mid-Atlantic states. For example, 83 percent of planners polled said expansion of existing sand and gravel operations was seldom or never opposed, whereas 93 percent relayed that proposed crushed stone quarries are almost always opposed (from Wernsted, 2000, J. Planning Educ. & Res., 20:77-87).

reserves (balanced or excess counties). For many counties in eastern and southwest-central Colorado, this deficit is strictly geologic, meaning there simply aren't enough quality deposits from which to extract the aggregate. 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. The national average cost of aggregate is $4 to $6 per ton. Deficit counties can expect to pay an extra $0.33 per ton of aggregate imported from nearby sources. Counties that must purchase aggregate from a distribution center or sales yard (such as those in Florida or Texas for example) where the material has been transported a great distance 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. Counties then must strive for long-term resource management and early protection of aggregate resources.

Soda Ash and Sodium Bicarbonate

Colorado is second in the world only to Wyoming in raw material for soda ash manufacture and is host to the only known natural source of sodium bicarbonate. Soda ash (Na_2CO_3) is used primarily in the manufacture of glass, soap and detergents, and other chemicals. Additionally, it is used to remove sulfur dioxide from power plant emissions. Sodium bicarbonate ($NaHCO_3$), also known as baking soda, is used in food products, animal feed, cleaning products, and pharmaceuticals.

Colorado soda ash and sodium bicarbonate are derived from nahcolite, a naturally occurring sodium bicarbonate mineral that is present in large quantities in the sedimentary rocks of the Piceance Creek Basin in northwestern Colorado. The nahcolite is disseminated in oil shale of the Eocene-age Green River Formation at depths of about 2,000 to 2,500 feet below the surface. It is estimated that 32 billion tons of nahcolite are present within the Piceance Creek Basin.

American Soda LLP, Rio Blanco County

American Soda LLP, formerly a subsidiary of Williams Companies, was acquired by Solvay America in September 2003. It is currently Solvay's only baking soda producer in the U.S. and is also a producer of soda ash (Solvay also operates a trona mine in Wyoming that produces soda ash). In 2003, American Soda shipped 550,000 tons of soda ash and 80,000 tons of sodium bicarbonate; a slight increase over production in 2002. Nahcolite is solution mined from 29 vertical wells that penetrate several nahcolite-rich oil shale beds of the Green River Formation. The average life of each well is three to three and a half years. The mine and plant employ 78 people and have a nameplate 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 U.S. Bureau of Land Management land. The estimated in-situ nahcolite resource is 3.5 billion tons, with over 1 billion tons of recoverable nahcolite. In April 2004 Solvay announced that it would mothball the American Soda operation.

Natural Soda AALA, Inc., Rio Blanco County

White River Nahcolite Minerals, LLC, a subsidiary of IMC Chemicals, has been producing sodium bicarbonate by solution mining for several years at a site close to American Soda's mine. In February 2003, White River Nahcolite was purchased for $20.6 million by Natural Soda AALA, Inc., a subsidiary of AmerAlia, Inc. In 2003 the plant produced 77,513 tons of sodium bicarbonate. High grade nahcolite (>80%) is recovered from the "Boise Bed" of the Green River Formation—a bed that is not present at the American Soda LLC plant. Dissolution of the nahcolite is through horizontal drill holes along the base of the Boise Bed. The mine's designed capacity is 125,000 tons per year. Both food grade and industrial grade products are produced. Natural Soda, Inc. 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.

GYPSUM

American Gypsum, Eagle County

Centex Construction Products Inc.'s American Gypsum operation produced 590,000 tons of gypsum in 2003 from its mine near the town of Gypsum. This represents about a 7 percent increase in production over 2002. 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 in the town of Gypsum can operate for at least another 20 years. 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 mine and plant employ approximately 120 people. The bedded gypsum deposit is within the Eagle Valley Formation evaporite sequence of Pennsylvanian age.

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 50,000 tons. The majority of the material quarried is sold within the state to the cement industry.

Other Colorado Gypsum Producers

Smaller gypsum mines in Fremont County produce gypsum primarily for agricultural uses. The gypsum is mined from the Cretaceous Dakota Sandstone, Jurassic Ralston Creek Formation, and Pennsylvanian Eagle Valley Evaporite.

CEMENT

The main cement manufacturers in Colorado are Holcim (U.S.) Inc. and CEMEX, Inc. Portland cement production has held between 2.5 and 3.0 million tons for the past several years (Fig. 44). The amount of masonry cement manufactured in the state showed a dramatic decrease to less than 30 thousand tons in 2002. Total production figures for 2003 are not available to the public at this time.

Holcim (U.S.), Inc., Fremont and Larimer Counties

The Portland Plant near Florence is operated by

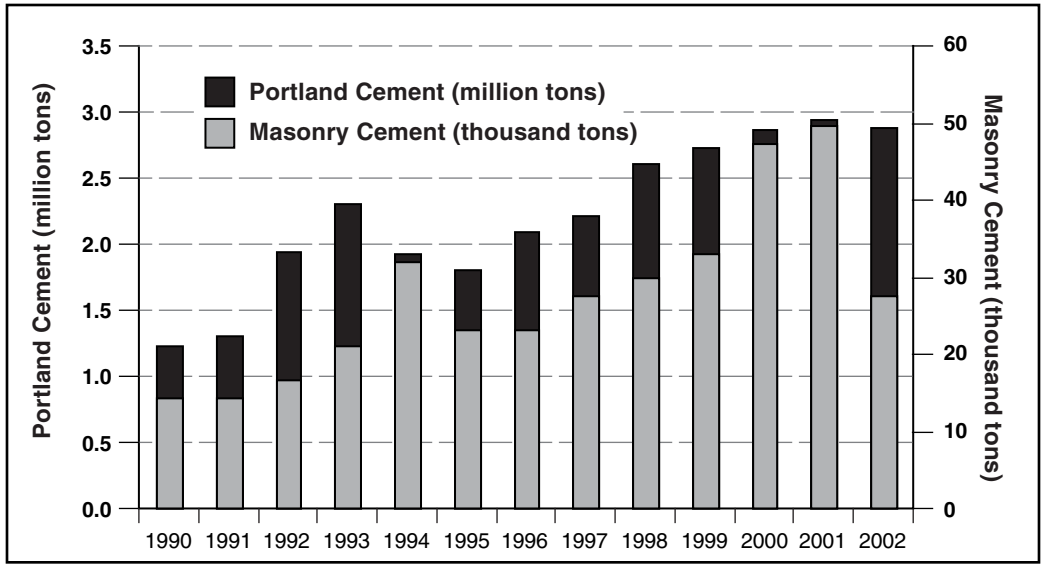


Figure 44. Production of portland cement and masonry cement in Colorado, 1990—2002.

Figure 45. Holcim's Portland cement plant and limestone quarry in Fremont County. The large structure on left is a pre-calcining tower. Fort Hays Member (limestone, lower bench), and Smokey Hills Member (overburden, upper bench) of the Niobrara Formation crop out in the quarry in the foreground; the Wet Mountains rise in the background.

Holcim (U.S.), Inc. Cement is produced using the dry method in their processing plant (Fig. 45), which has a capacity of 1.9 million tons per year. In 2003, the plant produced just over 1.2 million tons of cement, employed about 180 people, and has not lost production time to accidents in 500 days. 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.

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 2003 was 515,000 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 plant has not begun as of early 2004.

Clay and Shale

Common clay is used mainly to make bricks and tiles. Common clay is mined primarily in eastern Colorado, especially near the Front Range in Jefferson, Elbert, Douglas, El Paso, Pueblo, and Fremont counties. Figure 46 shows Colorado clay production from 1990 through 2003. In 2003, mines in Colorado produced a total of nearly 236,000 tons of common clay, which represents an increase of about 18 percent from 2002. The value of this clay was estimated at $1.26 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.

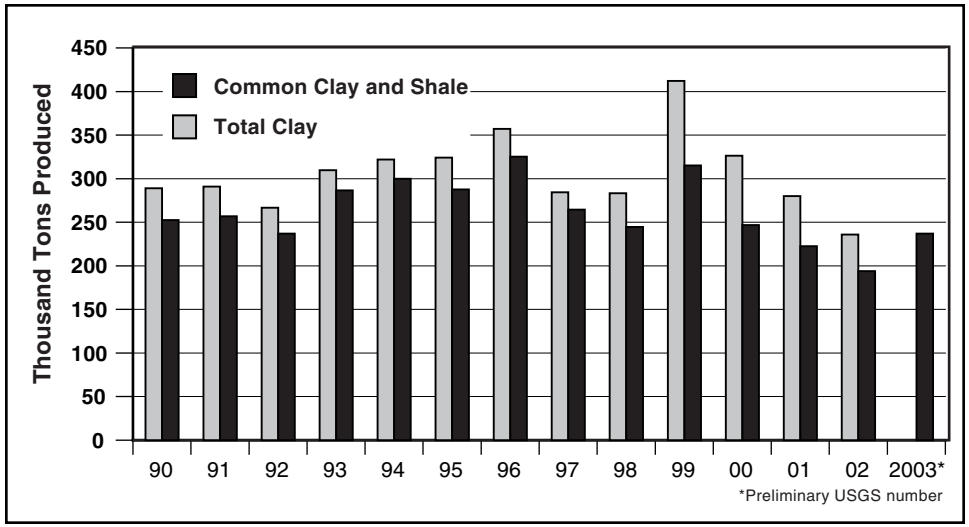


Figure 46. Total clay production vs. common clay and shale production. The difference between the two represents production of bentonite, kaolin, and other clay minerals.

Higher quality clays have also been produced from the Dakota and Dawson Formations. Both are locally sources for refractory clay, although current market demands do not warrant active mining of these deposits. Additionally, bentonite layers are found in the Jurassic Morrison Formation and Cretaceous Pierre Shale, although only the Pierre Shale is currently being mined. In Fremont County, bentonite is associated with altered volcanic rocks. Complete production data for bentonite is not available to the public.

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.

Figure 47. Girl Scouts and (from left to right) Representative Gregg Rippy (whose district includes the town of Marble and the Yule quarry), Senator Lew Entz (Senate Sponsor), and Representative Betty Boyd (House Sponsor) gathered to watch Governor Bill Owens sign into law Colorado Yule Marble as the official State Rock.

Dimension Stone

In 2003, 17,200 tons of dimension stone with an estimated value of over $2 million were quarried in Colorado. The principal Colorado dimension stones include marble, sandstone, granite, and rhyolite (a light-colored volcanic rock).

Yule Quarry, Gunnison County

The Yule quarry is operated by Sierra Minerals Corp. In 2003, the Yule quarry produced 24,700 cubic feet (2,100 tons) of world-renown white marble. This represents a significant downward turn of about 45 percent from 2002. The number of employees at the quarry similarly fell from 13 to 7. 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. In 2002, Sierra was awarded a contract to cut a massive block of marble to replace the cracked Tomb of the Unknowns in Washington, D.C. (carved from Yule marble in 1931). Two blocks have already been cut, but both proved to be imperfect, so mining crews are searching the quarry for yet another suitable block, which they hope to have cut by the summer of 2004. Carving of the massive stone is to be carried out in the town of Marble (site of the Yule quarry) over a period of 18 to 24 months. Platforms will be set up to allow the general public to watch the carving process. Other structures utilizing the Yule marble include the Lincoln Memorial, the Colorado State Capitol and Annex buildings, and Denver International Airport. The majority of the Yule marble is marketed under the name "Colorado Yule Marble". Very high quality stone shipped to Italy is marketed under the name "Sierra White."

Late in 2002, a local Girl Scout troop began a campaign to create a bill to make Colorado Yule Marble the official State Rock. Governor Bill Owens signed this bill into law in March of 2004 (Fig. 47). The addition of the white Yule Marble completes Colorado's patriotic theme of red (State Mineral, rhodochrosite), white, and blue (State Gemstone, aquamarine).

Colorado Rose Red Corp., Larimer County

The Colorado Red Rose quarry is a relatively small operation that produces blocks of red granite for use as countertops, monuments, and building stone. Annual production from the quarry is about 1,000 tons, most of which is sold in Colorado. The Red Rose quarry uses an innovative technique to cut the stone. Having tried unsuccessfully to utilize traditional methods, quarry founder Daniel Liesveld invented and patented an automated Water Jet Channeler, which uses a very small stream (the size of a pencil lead) of highly pressurized water to erode the stone crystal by crystal. The channeler may be used either horizontally or

vertically and improves both the speed and quality of production and may be run unattended. A typical block about 10 x 5 x 3 feet may be cut (channeled) on all four sides and removed from the deposit using plugs and feathers in less than two days. Colorado Rose Red celebrated 20 years of water jet channeling in 2002.

Other Colorado Dimension Stone

Sandstone continues to be quarried in several places in Colorado, especially along the base of the Front Range in Larimer and Boulder counties. The Permian-age Lyons Sandstone is quarried in flat slabs and used as building stone, walkway stone, and decorative wall facing. The Cretaceous-age Dakota Sandstone is quarried for similar uses in several places around the state. Alabaster is quarried from the Permian Lykins Formation at a small mine near Fort Collins by Colorado Alabaster Supply. In 2003 the company produced just under 200 tons of stone. Their alabaster is used mainly for sculpting and is marketed both locally and nationwide. The White Banks Mine in Pitkin County also produces alabaster, as well as dark-colored marble, and quartz. The Eocene-age Castle Rock rhyolite is quarried by the Ames Construction Company near the town of Castle Rock.

Industrial Sand and Gravel

In 2003, about 69,445 tons of industrial sand and gravel were produced in the state. This is a decline of about 3 percent from 2002. Monetary value of commodity is not available to the public. Colorado's leading industrial sand company is the Ohio-based Oglebay Norton Company, which markets "Colorado Silica Sand," specialty industrial sand that is used for hydraulic fracturing of oil and gas wells, filter media for water purification plants, 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 silica sand is derived from Quaternary-age eolian deposits composed of mostly well-sorted and well-rounded grains of quartz. However, active mining of the silica sand stopped in 2001. The company currently operates solely from its stockpile, which has three to four years of reserves remaining. Oglebay Norton is currently exploring a silica sand prospect northeast of Colorado Springs. No mine permits have been applied for as of yet.

Decorative Stone

Decorative stone has become a more important part of the Colorado minerals industry in recent years. Decorative stone is rock that is used primarily for landscaping purposes. 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 decorative stone mines and quarries are located in Colorado. Decorative stone mines and quarries are typically small operations. No specific production figures are available for statewide decorative stone production.

GEM AND SPECIMEN MINERALS

According to preliminary estimates made by the U.S. Geological Survey, the total value of reported gemstone production in Colorado in 2003 was $274,000. This is an increase of about three percent over 2002.

Diamonds

Kelsey Lake Mine, Larimer County

No mining took place at the Kelsey Lake diamond mine in 2003. The Kelsey Lake Mine, adjacent to the Wyoming border, stopped production in April 2002 because of a lack of financing. As of the end of 2003, the mine was still in care-and-maintenance mode. There are no immediate plans to begin production again.

The two kimberlite bodies, each about 10.5 acres in size, are located about one-half mile apart. The ore continues to a depth of at least 350 feet according to drill data released previously by the company in press reports.

In 1996, a 28.3-carat light-yellow diamond was recovered at the mine—the fifth largest diamond ever found in the U.S. A slightly smaller 28.2-carat stone was also discovered. This stone was cut into a 16.86-carat polished diamond, the largest finished diamond that a North American mine has ever produced. The Kelsey Lake Mine is an open pit operation on two kimberlite pipes. The two kimberlite bodies, each about 10.5 acres in size, are located about one-half mile apart. The ore continues to a depth of at least 350 feet according to drill data released previously by the company in press reports. The reserve is estimated at 18.7 million tons grading 3.4 to 4.6 carats per 100 tons of kimberlite ore.

Other Specimen and Gem Minerals

Amazonite

Amazonite and smoky quartz are specimen minerals found in pegmatites within the Pikes Peak batholith 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 later sold at gem and mineral shows, in rock shops, and on the internet.

Aquamarine

Aquamarine, a form of beryl and a silicate mineral, 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. The aquamarine crystals are found in large miarolitic cavities within pegmatites associated with Tertiary-age granite stocks. This locality is considered one of the finest in North America for collecting this prized mineral, and specimens are displayed in many museums.

Rhodochrosite

Colorado's State Mineral is rhodochrosite (manganese carbonate, $MnCO_3$). The Sweet Home Mine near the town of Alma in Park County continues to produce the most prized specimen-quality rhodochrosite crystals in the world. Since 1991, the former silver mine has produced the beautiful cherry red crystals from open cavities in hydrothermal quartz-calcite-sulfide veins. Some of the larger crystals have commanded prices over $100,000, and one, the "Alma King," is rumored to have fetched nearly $1 million.

Turquoise

A small turquoise mine is currently operated near Cripple Creek by the Bad Boys of Cripple Creek Mining Company, Inc. The company also produces and sells jewelry made from this turquoise. The Florence Mine is another small operation near Cripple Creek. Roughly 30 pounds of turquoise were produced from this mine in 2003, although production during other years has often amounted to a few hundred pounds. Other inactive turquoise deposits in the state include the King Mine in Conejos County, the Turquoise Chief Mine in Lake County, and Hall Mine near Villa Grove in Saguache County.

Helium

Helium is used for several purposes including cryogenic applications, pressurizing and purging, welding cover gas, and controlled atmospheres. The total U.S. private production of Grade-A helium in 2003 was estimated by the U.S. Geological Survey to be about 3.07 billion cubic feet, with an estimated value of $285 million. Although production remained fairly consistent, total value rose by about 13 percent over 2002. Grade-A helium is produced at the Ladder Creek 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. Colorado production data is not available for publication.

RELATED CGS PUBLICATIONS

PUB NO	YEAR	TITLE	AUTHORS	DESCRIPTION
COAL				
IS 55	2001	Colorado Coal Directory 2000	C.J. Carroll and B.L. Widmann	Describes and lists all the active coal mines in Colorado with information on each mine's location, operating company, mine type, etc.
IS-64	2002	Historic Coal Mines of Colorado	C.J. Carroll and M.A. Bauer	This CD-ROM details the 1,736 coal mining operations in Colorado from 1864–2002.
RS 41	2003	Available Coal Resources of the Williams Fork Formation in the Yampa Coal Field, Routt and Moffat Counties, Colorado	Papp, Kinnes, Marston & Marston	CD-ROM, describes the amount of coal available for mining in the Yampa Coal Field.
SP 51	2001	Coal and Coalbed Methane in Colorado	Colorado Geological Survey	The purpose of this interactive CD-ROM is to provide middle school students with a technical overview of coal and coal-derived products
SP 54	2004	2003 Summary of Coal Resources in Colorado	C.A. Carroll	This report is an update of SP41 published in 1995 and contains information on coal production, coal mining and coal quality.
GAS AND OIL				
B 51	1996	Guide to the Petroleum Geology and Laramide Orogeny, Denver Basin and Front Range, Colorado	R.J. Weimer	Two field trip guides to the Petroleum Geology and Laramide Orogeny, Denver Basin and Front Range.
IS 50	1999	Oil and Gas Fields of Colorado Statistical Summary through 1996	A.D. Lawson and H.T. Hemborg	A statistical summary through 1996 of oil and gas fields of Colorado.
MS 30	1996	Basement Structure Map of Colorado with Major Oil and Gas Fields	H.T. Hemborg	Map shows basement structure in Colorado-structure contours on top of Precambrian basement rock.
MS 33	2002	Oil and Gas Fields Map of Colorado	L.L. Wray, A.D. Apeland, H.T. Hemborg, and C.A. Brchan	Oil and gas fields map depicting basin outlines, field names, status, producing formations, and product pipelines
OF 01-17	2001	The Coalbed Methane Potential in the Upper Cretaceous to Early Tertiary Laramie and Denver Formations, Denver Basin, Colorado	L.L. Wray and N.V. Koenig	This CD-ROM compiles existing geologic information regarding the coalbed methane resources of the Denver Basin.
OF 02-15	2002	Evaluation of Bottom-hole Temperatures in the Denver and San Juan Basins of Colorado	J. Dixon	This CD-ROM contains bottom-hole temperature (BHT) data from the Denver and San Juan Basins.
RS 34	1998	Penetration Charts of Selected Colorado Oil and Gas Fields	C.M. Tremain Ambrose	Plates contain data on 117 representative oil and gas fields located in all thirteen of Colorado's producing regions.
RS 43	2003	Paradox Basin, Colo., Maps, Cross Sections, and Database for Oil, Gas and CO_2 Fields	Phyllis K. Scott geometry as well as raw data.	Provides interpreted data to illustrate hydrocarbon traps and reservoir
SP 50	2000	Gas and Oil in Colorado	Colorado Geological Survey	This interactive CD-ROM provides middle school students with a technical overview of gas and oil resources in Colorado.

PUB NO	YEAR	TITLE	AUTHORS	DESCRIPTION
MINERAL RESOURCES				
IS 33	1992	Gold Panning and Placering In Colorado: How and Where	B.H. Parker	Written for the recreational panner and rockhounds. Explains how to pan for gold, recovery devices, placer mining methods, etc.
IS 62	2002	Digital Inventory of Industrial Mineral Mines and Mine Permit Locations in Colorado	J.W. Keller, R.C. Phillips, and K. Morgan	This digital inventory provides information on industrial mineral mines and mine permit locations.
IS 68	2004	Directory of Active Mines and Mine Permits in Colorado—2002	J.W. Keller	Lists operating mines, as well as mines with valid, active permits from DMG, that operate sporadically.
OF 02-12	2002	Sand and Gravel Resources Adjacent to the Colorado River Valley, Garfield County, Colorado	B.L. Widmann	The purpose of this CD-ROM is to assist Garfield County planners, citizens, and resource developers evaluate sand and gravel deposits.
RS 28	1990	Gold Occurrences of Colorado	M.W. Davis and R.K. Streufert	Text discusses classification of gold occurrence and important gold districts by age. Includes table of occurrences.
RS 35	1998	Alkalic Igneous Rocks of Colorado and Their Associated Ore Deposits	J.A. Cappa	Mineral deposits associated with alkalic rocks of major economic importance to Colorado's mining industry.
RS-37	2000	Geology and Mineral Resources of Gunnison County, Colorado	R.K. Streufert with W. Eakins and H.T. Hemborg	This comprehensive report summarizes the geology and mineral resources of Gunnison County.
RS-40	2001	Geology and Mineral Resources of Park County, Colorado	L.A. Scarbough	This comprehensive report summarizes the geology and mineral resources of Park County
SP-47	1998	An Introduction to Mining and Minerals in Colorado	Colorado Geological Survey	This interactive CD-ROM's interface is a geologic map of Colorado with infor mation about minerals, mines, and the uses of minerals.