Information Series 67

Colorado Mineral and Mineral Fuel Activity

2002

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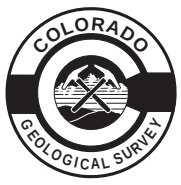

Cover: Hayden Power Plant, Hayden, Routt County; Exploration drilling for precious metals at Webster Pass in the Montezuma mining district, Summit County, 2001

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FOREWORD

The Department of Natural Resources is pleased to present Colorado Geological Survey Information Series 67, *Colorado Mineral and Mineral Fuel Activity, 2002.* Its purpose is to describe exploration, development, and production activity of the gas and oil, coal, and mineral industries of the state in 2002. The report also includes information on the economic impact of these industries to the state.

This report is prepared as part of the legislative direction to the Minerals, Energy, and Geology Policy Advisory Board. The staff of the Mineral and Mineral Fuel Resources Section of the Colorado Geological Survey gathers this information through the report 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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INTRODUCTION AND ECONOMIC FACTORS

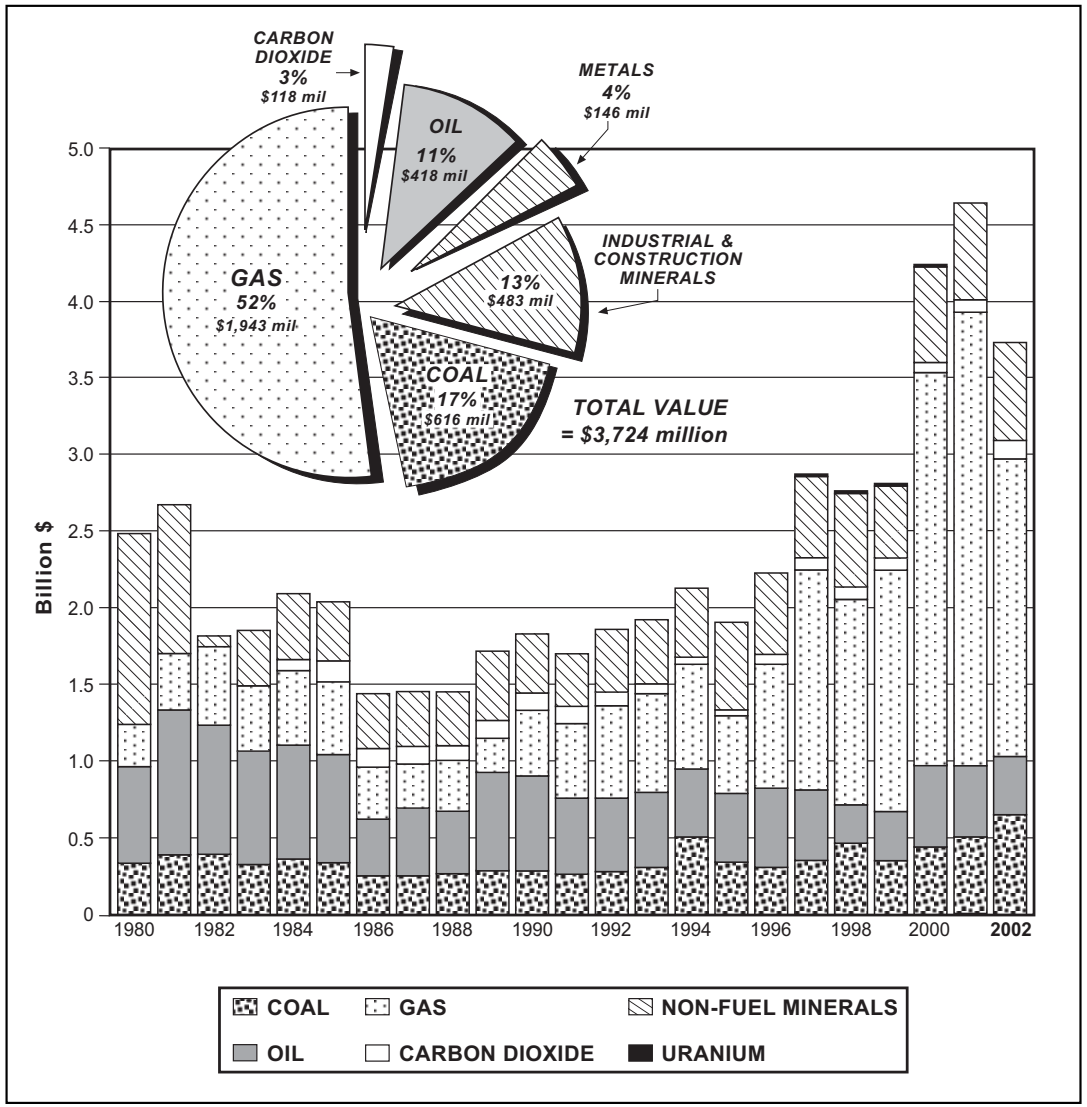


Figure 1. Value of Colorado mineral and mineral fuel production, 1980—2002.

By James A. Cappa

The Colorado Geological Survey (CGS) Mineral Resources Section estimates the total value of 2002 mineral and mineral fuel production in Colorado to be $3,724 million, a 20 percent decrease from the (revised*) 2001 total value of $4,645 million (Figure 1).

Mineral fuel and carbon dioxide production values for 2002 are estimated at:

- oil—$417.6 million
- natural gas—$1,943 million
- carbon dioxide—$117.7 million
- coal—$616 million

The total estimated value of oil, natural gas, and carbon dioxide production in 2002 was $2,478 million, which is down 31 percent from the 2001 value of $3,610 million. Colorado natural gas production increased and oil production declined; however, both prices for gas and oil declined during most of 2002. The value of carbon dioxide production decreased from $122 million to $118 million, primarily due to decreased production.

Coal production increased from the 2001 level of 33.4 million tons to a record 35.2 million tons in 2002. Coal prices, which vary from mine to mine, are estimated at an average $17.50 per ton for 2002. The value of Colorado coal production is estimated at $616 million, up 23 percent from the 2001 value of $502 million.

The CGS and the U.S. Geological Survey Mineral Information Office estimate the value of the 2002 non-fuel mineral production to be $629 million. This figure is a 14.6 percent increase from the 2001 value of $540 million. Price increases for both molybdenum and gold were a factor in the increase of non-fuel mineral value.

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:

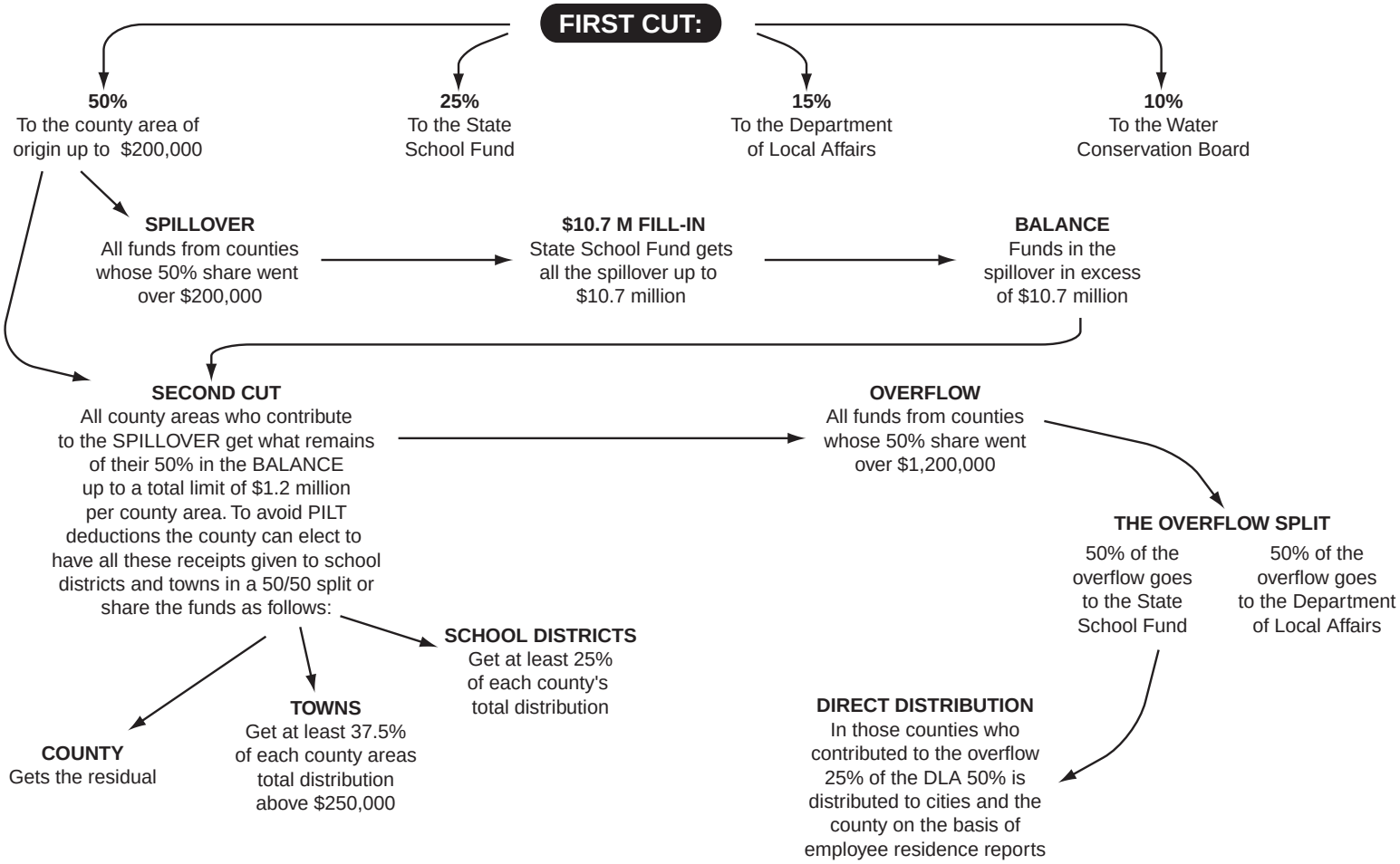


Figure 2a. Distribution of federal mineral lease revenues.

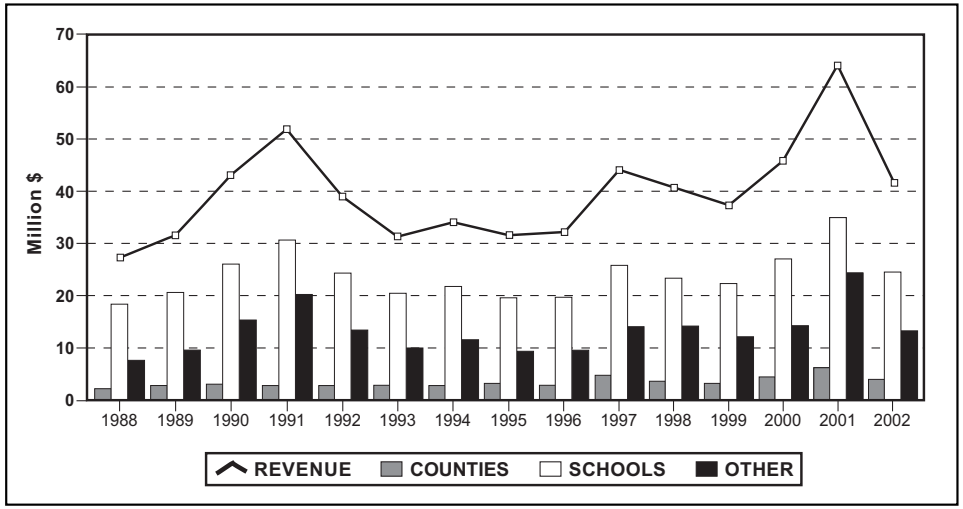


Figure 2b. Federal mineral lease revenue and distribution in Colorado, 1988—2002.

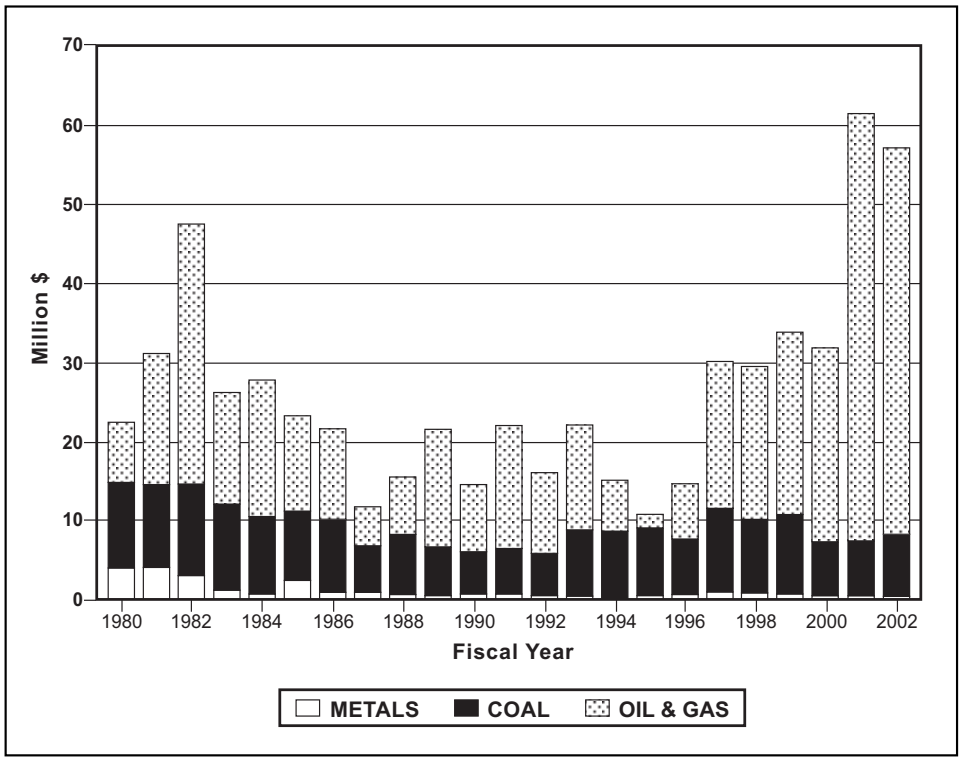


Figure 3. Colorado severance tax collections, 1980—2002.

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 2002 is $41.8 million, a 35 percent decrease from the 2001 value of $64.6 million. A detailed formula for the distribution of these revenues in included in Figure 2a. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (Figure 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 2002 were $57.1 million, down 7.7 percent from the 2001 severance tax collection of $61.9 million (Figure 3).

Estimated property taxes paid in 2002 to the counties from mineral and mineral fuel properties totaled $129.9 million (Figure 4). La Plata, Weld, and Clear Creek counties all received over $10 million each in mineral property tax revenue. All Colorado counties except Denver County receive revenue from mineral related property taxes.

The University of Colorado's College of Business Administration estimates employment in the mineral and mineral fuel industries in

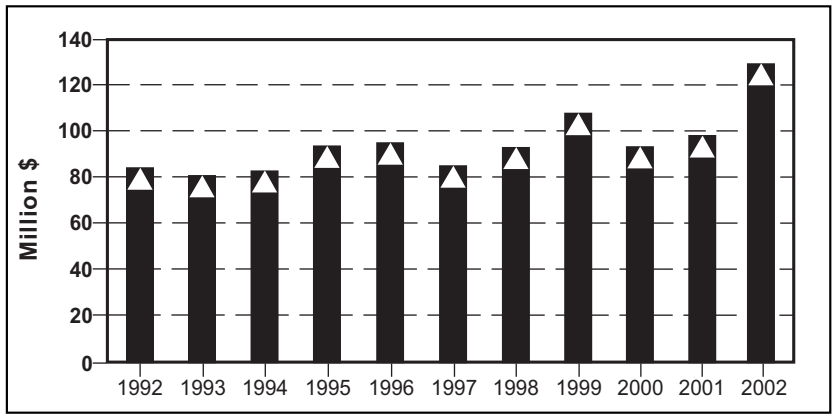


Figure 4. Property tax revenues from mineral properties, 1992—2002.

2002 to be 14,900 workers, a 6.4 percent increase from the 2001 level of 14,000 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.

** The 2001 production values for all commodities are revised from the Colorado Geological Survey* Mineral and Mineral and Fuel Activity Report *for 2001. This report is written in March 2003. Oil and gas and non-fuel mineral production values included in this report are always estimates for the preceding year. Final production values for 2002 will be available at the end of 2003.*

GAS, OIL, AND CARBON DIOXIDE

Executive Summary of Hydrocarbon Production Statistics

2002 Statistics	Value*	Percent Change from 2001
Total natural gas production (incl. coalbed methane)	844 BCF(e)	+2.4
Coalbed methane (CBM) production	398 BCF(e)	+1.5
Conventional gas production	446 BCF(e)	+3.4
Oil production	17.7 MMBO(e)	-9.7
Carbon dioxide production	294 BCF(e)	-3.3
Value of total gas production	$1,943.0 million(e)	-35.5
Value of CBM production	$994.2 million(e)	-32.2
Value of crude oil production	$417.6 million(e)	-11.3
Value of carbon dioxide production	$117.7 million(e)	-3.3
Estimated Total Value of Production	$2,478.3 million(e)	-31.3

2001 Statistics	Value*	Percent Change from 2000
Total natural gas production (incl. coalbed methane)	824 BCF	+6.9
CBM production	392 BCF	-4.4
Conventional gas production	432 BCF	+19.7
Oil production	19.6 MMBO	+2.6
Carbon dioxide production	304 BCF	-2.1
Value of total gas production	$3,013.4 million	+ 16.7
Value of CBM production	$1,459.2 million	+16.8
Value of crude oil production	$470.8 million	-12.4
Value of carbon dioxide production	$121.7 million	+22.9
Total Value of Production	**$3,605.9 million**	**+12.1**

*BCF = billion cubic feet, MMBO = million barrels of oil, (e) = estimate

By Phyllis K. Scott

Introduction and Review of the Year 2001

(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 21.)

In 2001, the total value of produced natural gas, including coalbed methane (CBM), crude oil, and carbon dioxide (CO_2) climbed to a record high $3.61 billion (Figure 5). The value of produced natural gas (both conventional and CBM) accounts for 84 percent of this total, oil (13 percent), and CO_2 (3 percent). The contribution of high prices during the first half of 2001 offset the dramatic price plunge that culminated in the lowest gas prices in two years and the greatest one-day drop in oil prices in a decade in late September.

The year 2001 began with soaring natural gas prices; the weighted average statewide price for the month of January was $9.30/thousand cubic feet (MCF), or $8.74/million Btu (MMBtu) in response to high winter demand, low gas storage levels, and a deficient infrastructure. Gas prices then dropped steadily, reaching a low of $1.31/MCF ($1.23/MMBtu) in October 2001, which probably represented an over correction to the previous high prices and a response to the September 11 terrorist attacks.

Oil prices were more stable throughout the year and averaged $25.61/barrel for the first three quarters; the events of September 11 resulted in price declines, but not production declines, with an average low price of $17.33/barrel in December 2001, and an average fourth quarter price of $18.12. Carbon dioxide values averaged $0.40/MCF in 2001.

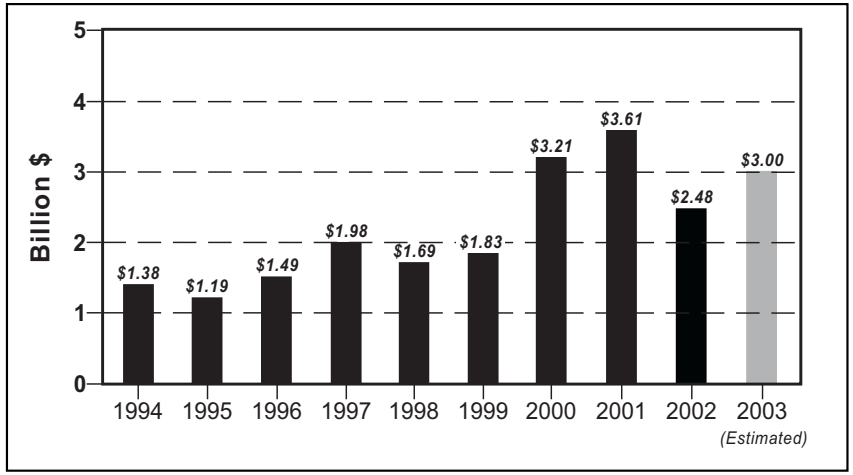


Figure 5. Colorado gas and oil production values 1994–2003 (COGCC).

The year 2001 saw a 68 percent increase in the basis differential between the average price for natural gas in Colorado and the price at Henry Hub in Louisiana. The average annual basis differential was minus $0.44/MMBtu in 2000 and minus $0.74/MMBtu in 2001, and it continues to increase (it averaged minus $0.97 in 2002).

Overview of Year 2002

The estimated value of the oil, gas, and CO_2 produced in Colorado in 2002 is $2.48 billion, 31 percent less than the production value of 2001. Seventy-eight percent of this total is from both conventional natural gas and CBM, 17 percent from oil, and 5 percent from CO_2. Estimated production volumes total 844 BCF gas (of which 398 is from CBM and 446 is from conventional natural gas), 17.7 MMBO, and 294 BCF CO_2 (data from Colorado Oil and Gas Conservation Commission—COGCC).

Gas prices were more stable in 2002 with an average price of $2.42/MCF ($2.29/MMBtu). Monthly prices fluctuated from a low of $1.79/MCF in September to $3.79/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 probably reflect increased demands due to the unusually cold, snowy winter in the eastern United States in 2002–2003. Oil prices averaged $23.52/barrel for the year, increasing throughout the year from a low of $17.16/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 increased from an average of minus $0.77 in 2001 to minus $0.97 in 2002, reflecting the continuing oversupply problem for Rocky Mountain producers. The average monthly basis differential peaked in October 2002 at minus $1.85/MMBtu.

Colorado Petroleum Statistics for the Years 2001 and 2002

The following summary of Colorado petroleum statistics for the years 2001 and 2002 measures the ways in which the industry responded to the dramatic price declines, a period of economic slow-down, and uncertainty in world conditions.

Final 2001 year-end numbers, compiled by the COGCC, showed the decline of the short-lived recovery in the petroleum industry, particularly in the natural gas sector. Record natural gas prices of late 2000 and early 2001 declined throughout the year to rock-bottom gas prices in the last half of 2001. Oil prices also declined throughout the year, but not as drastically. Production volumes generally increased throughout the year; however, the declining prices caused the monthly production values to decrease dramatically in the first half of the year for natural gas and in the last four months of the year for oil.

Natural Gas and Coalbed Methane

Natural gas prices rose to historically high levels in late 2000 and into the first quarter of 2001. The average price for Colorado natural gas in January 2001 was $9.30/MCF—a record high. After that month prices declined steadily, reaching a low of $1.31/MCF in October—a reaction to the September 11 terrorist attacks coupled with the declining economy. Prices remained fairly low (in the $2 to $3/MCF range) throughout most of 2002, but climbed to over $3/MCF in the last two months of 2002 and reached $4/MCF in early 2003. This trend can be seen in Figure 6, which shows the monthly average Colorado oil and gas prices for the years 2001 and 2002 .

Total natural gas production in Colorado has increased steadily since coalbed methane production began in the late 1980s. Figure 7 shows Colorado annual production volumes for oil, gas, and CO_2 from 1975 through 2002; it highlights the dramatic and steady rise of natural gas production since 1988. Figure 8 shows the production volumes of conventional natural gas and CBM (the two components of the natural gas production volumes) for each year since 1990. CBM production volumes rose steadily throughout the 1990s and surpassed conventional natural gas production volumes in 1997. However, in 2001 the conventional natural gas component again took the lead, probably as a response to increased drilling in conventional natural gas reservoirs in the Denver Basin and the Piceance Basin in recent years, and a decrease in drilling activity in the CBM plays in Las Animas and La Plata counties.

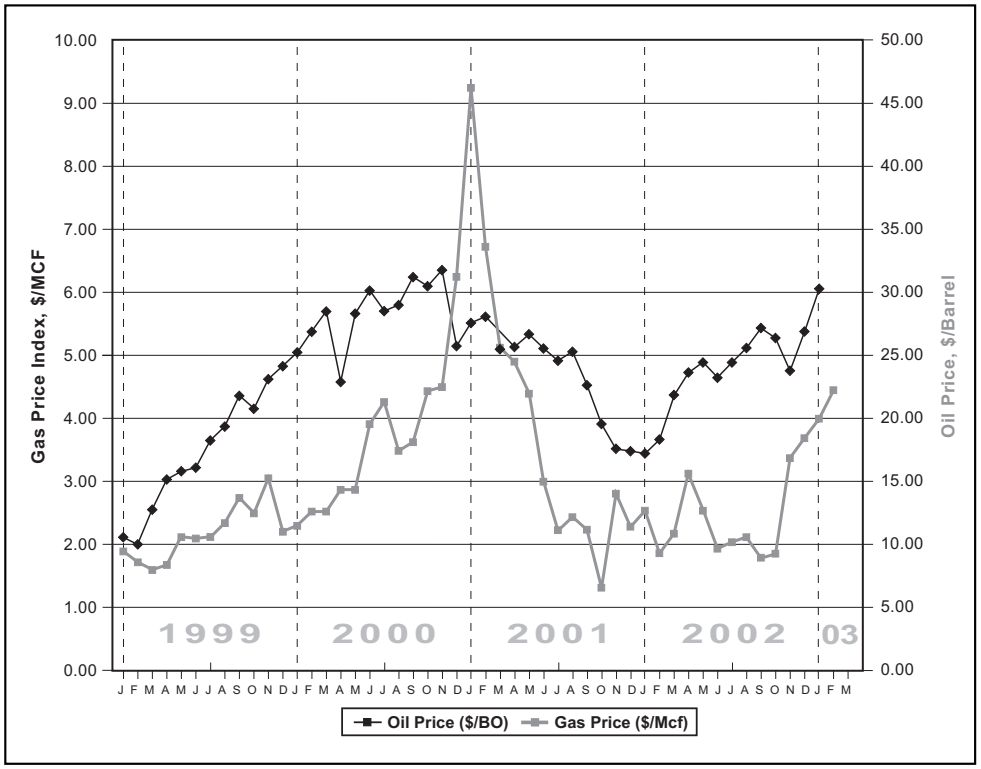
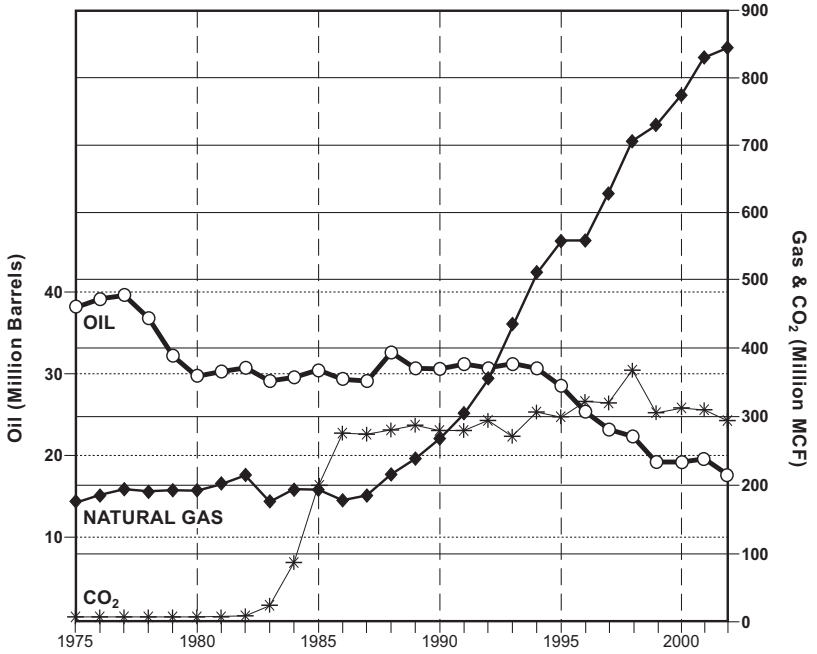


Figure 6. Natural gas and oil 12-region (national) composite spot wellhead prices, Jan.1999—Feb. 2003.



COMMODITY	1998 PROD	1999 PROD	2000 PROD	2001 PROD	2002 PROD (est)
Gas (total)	704 BCF	724 BCF	771 BCF	824 BCF	844 BCF
Oil	22.5 MMBO	19.1 MMBO	19.1 MMBO	19.6 MMBO	17.7 MMBO
CO_2	366.5 MCF	304.7 BCF	310.7 BCF	304.2 BCF	294.0 BCF

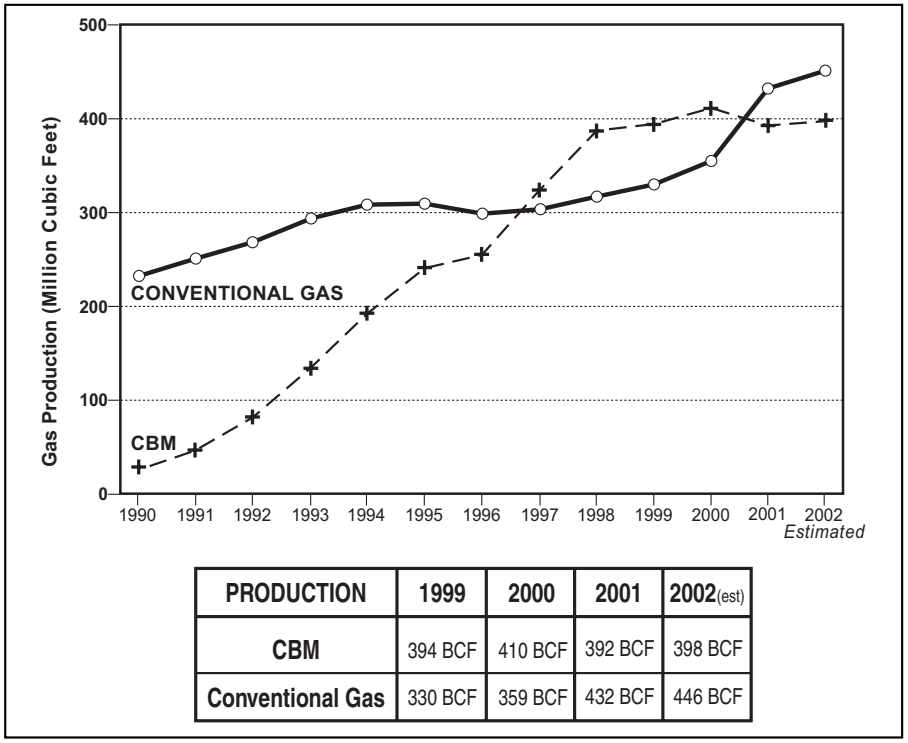
Figure 7. Colorado annual natural gas, oil and carbon dioxide production; 1975—2001 (COGCC).

Counties with the highest number of drilling permits are discussed and tabulated later in this report (see Table 5). CBM production is described in more detail later in this report.

Even though prices dropped steadily in 2001, monthly natural gas production showed a general upward trend throughout the year, as shown in Figure 9. The figure also shows the value of the total natural gas production (both conventional and CBM) for each month. In January 2001, natural gas prices averaged $9.30/MCF in Colorado and the production value soared for that month. Production values declined through 2001 as a result of falling prices, even as production volumes increased. The year 2002 showed more stable monthly production values and production volumes.

Production numbers and values for 2001 in Colorado are summarized below for natural gas and CBM (also see Figure 7):

- 824 BCF of natural gas and CBM produced (+6.9 percent from 771 BCF in 2000);
- 392 BCF of CBM produced (included in total above and represented in a decline of 4.4 percent from 410 BCF in 2000);
- $3.01 billion generated from natural gas and CBM production (a 16.7 percent increase from final 2000 production value numbers as reported by COGCC); and
- $1.46 billion generated from CBM production alone (a 16.8 percent increase from final 2000 production value numbers as reported by COGCC).



PRODUCTION	1999	2000	2001	2002(est)
CBM	394 BCF	410 BCF	392 BCF	398 BCF
Conventional Gas	330 BCF	359 BCF	432 BCF	446 BCF

Figure 8. Coalbed methane and conventional reservoir gas production, 1990–2001 (COGCC).

Estimated production numbers and values for 2002 in Colorado are summarized below for natural gas and CBM:

- 844 BCF of natural gas and CBM produced (a 2.4 percent increase from 2001);
- 398 BCF of CBM produced (included in total above and representing a 1.5 percent increase from 2001);
- $1.94 billion generated from natural gas and CBM production (a decline of 35.5 percent from 2001); and
- $0.99 billion generated from CBM production alone (a decline of 32.2 percent from 2001).

Crude Oil

Oil production in Colorado has slowly declined from a high of 39.5 million barrels of oil (MMBO) in 1977 (Figure 7). The graph also shows the trend of oil production in the state for the past 26 years.

Production numbers and values for 2001 in Colorado are summarized below for crude oil:

- 19.6 MMBO (an increase of 2.6 percent from 19.1 MMBO in 2000); and
- $471 million (a decrease of 12.3 percent from $537 million in 2000).

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

- 17.7 MMBO (a decrease of 9.7 percent from 2001); and
- $418 million, a decrease of 11.2 percent from 2001 (Data from COGCC)

Carbon Dioxide

Annual carbon dioxide (CO_2) production for 2001 totaled 304.2 BCF—a 2.1 percent decrease from the 2000 total of 310.7 BCF (Figure 7). The total value from CO_2 production in 2001 was $121.7 million—an increase of 22.8 percent from final 2000 value of $99.1 million reported by the COGCC.

Estimated production numbers and values for 2002 in Colorado are summarized below for CO_2:

- 294.3 BCF (a decrease of 3.2 percent from 2001); and
- $117.7 million (a decrease of 3.2 percent from 2001).

Coalbed Methane (CBM)

Included in the production numbers for natural gas is the production of naturally occurring methane gas from subsurface coal beds. Known as coalbed methane (CBM), this subset of natural gas is becoming increasingly more important in Colorado. Figure 8 shows a ten-year comparison of CBM and conventional natural gas production in Colorado. This relationship is all the more impressive given the fact that CBM production has only been in existence in volumes substantial enough to report during the past decade. Within only seven years, CBM production surpassed that of conventional natural gas in Colorado. However, 2001 saw a resurgence in the production of conventional natural gas, which once again surpassed CBM production as shown in Figure 8.

In 2001, 48 percent, or 391 BCF of the total 824 BCF of natural gas produced in Colorado, came from CBM wells (COGCC). Nationwide, CBM was produced from over 20,000 wells—accounting for 7.9 percent (1,562 BCF) of the total U.S. dry natural gas production of 19,779 BCF in 2001. CBM reserves in the United States are estimated at 17.5 trillion cubic feet (TCF) or

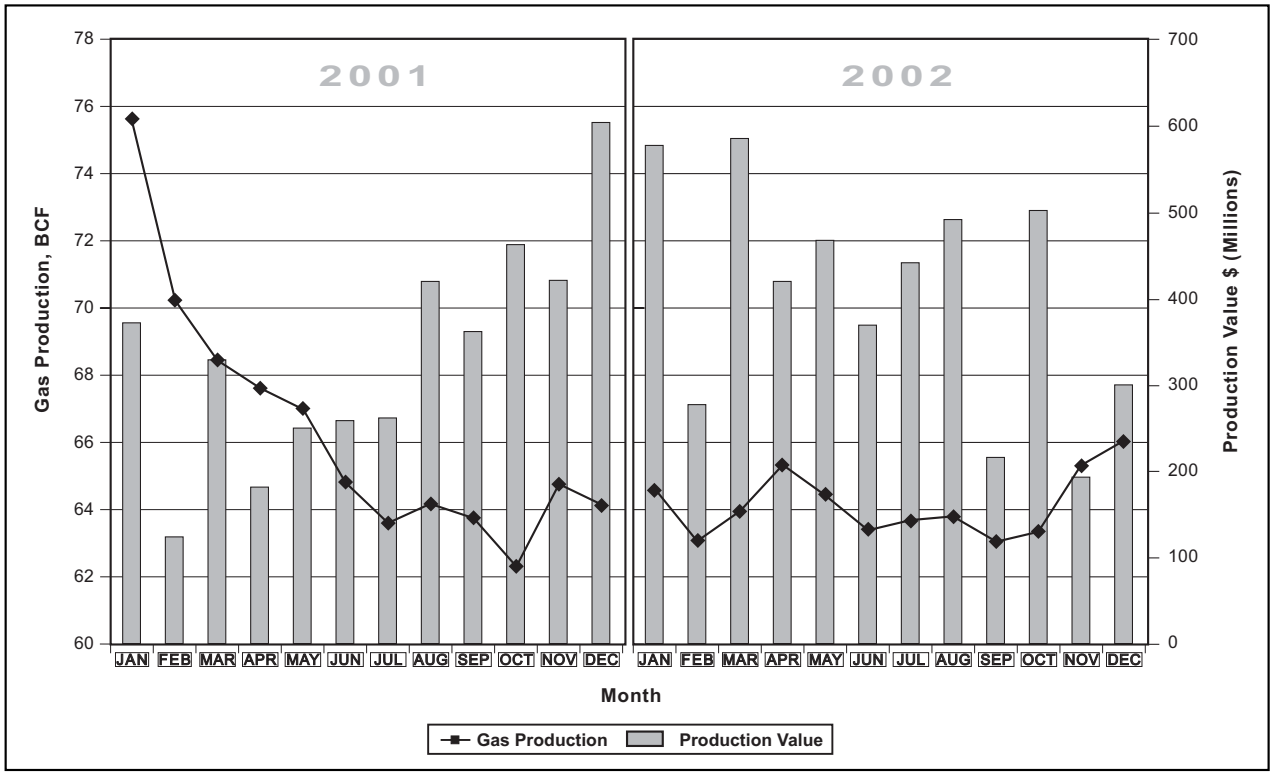


Figure 9. Monthly gas production and production value, 2001-2002 (COGCC).

9.5 percent of the U.S. dry natural gas reserves of 183.5 TCF. This estimate for 2001 represents a 12 percent increase over the 2000 reported CBM reserves of 15.72 TCF in the US, and more than a four-fold increase over the 1989 estimated reserves of 3.7 TCF. In 2001 Colorado ranked first among all the states in CBM reserves and second in CBM production as shown in Table 1 (U.S. Department of Energy, Energy Information Administration [DOE/EIA], U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2001 Annual Report).

Table 1. Coalbed methane production and reserves in billion cubic feet, 1989—2001 (DOE/EIA). Note: EIA values for production differ from those of the COGCC.

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

** Includes Oklahoma, Pennsylvania, Utah, Virginia, West Virginia, Wyoming, Kansas, and Montana*

CBM is natural gas (methane) that is produced specifically from subsurface coal beds that contain significant quantities of methane gas—chemically identified as CH_4. Long considered an undesirable and dangerous by-product of many Colorado coals, this colorless and odorless gas, often capable of spontaneous combustion, was responsible for many coal fires and mine explosions. The petroleum industry, in conjunction with state and federal agencies, developed techniques to extract methane from coal beds using drill rigs and subsurface completion technologies similar to what is used to produce natural gas from conventional reservoirs—predominantly sandstones and limestones. Coal beds were identified as unconventional gas reservoirs—subject to tax credits in the late 1980s and early 1990s. Though the tax credits provided the initial economic impetus to explore for these unconventional reservoirs, successful drilling and completion technologies allowed the extraction of CBM to become fully profitable even after the tax credits expired in the early 1990s.

Coal-bearing units underlie approximately 28 percent, or 29,600 square miles, of Colorado. As such, it is no surprise that CBM exploration and development is so prolific in the state. There are a number of reservoir components related to subsurface coal beds that control how methane is trapped in the coal and if it can be recovered economically. Factors such as the preserved gas content in the coals, the amount of water in the coals, the ability of both water and gas to flow to a well bore, the reservoir pressure exerted on the coal, and the thickness and depth of the coal are all significant. As the number of successful CBM operations continues to increase in Colorado, it becomes apparent that these critical factors exist, in some unique combination, for all coals.

Given the fact that over 1,700 historic coal mines have been in operation in the state over the past 120 years, ample data can be derived from those operations. The presence of methane gas and dust in coal mines, capable of spontaneous combustion, caused numerous explosions and fires in the mines. Other observable indications have been documented as well. Figure 10 shows naturally occurring methane bubbling up in the Little Snake River near the Wyoming border in northern Colorado. Residents along the river report seeing these methane seeps in the river for over 70 years. Seeps such as this are an indication that methane is trapped in the coal beds that lie directly under the Little Snake River.

Figure 10. Naturally occurring methane gas seeps causing bubbles in the Little Snake River in northern Colorado near the Wyoming border. (Photo by Laura Wray)

Figure 11 shows a surface pumping unit on a CBM well that lifts the water and gas to the surface. The presence of such a pumpjack usually suggests that the coals contain a significant amount of water. Once the water has been removed from the coals, the pumping unit can be removed and the methane gas is able to rise freely up the production pipe to the surface collection system known as a "Christmas tree" (Figure 12). The presence of a Christmas tree may also indicate a CBM well that produces very little water and thus needs no surface lifting equipment such as a pumping unit.

The San Juan Basin of southwestern Colorado is the most significant coalbed methane producing region in Colorado. In the past five years, the Raton Basin of south central Colorado has grown into an important coalbed methane producing region. The greater Piceance Basin also has coalbed methane potential. In the past year, exploration interest has centered on the Sand Wash Basin and North Park Basin.

Figure 11. Surface pumping unit (pumpjack) on an Upper Cretaceous coalbed methane well. (Photo by Laura Wray)

Figure 12. Coalbed methane well surface equipment (i.e., Christmas tree), La Plata County, Colorado. (Photo by Laura Wray)

Twenty-five Year Production Trends for Colorado

Figure 7 summarizes production trends in Colorado for natural gas (including CBM), oil and CO_2 over the past 25 years. During this period of time, the US petroleum industry experienced several boom and bust cycles that were controlled primarily by changes in pricing and production quotas set by the Organization of Petroleum Exporting Countries (OPEC), as well as changes in regulations and government oversight.

Oil production in Colorado began to decline from a high of 39.5 MMBO in 1977 (Figure 7). There were no major discoveries in Colorado after 1977 that could effectively replace oil reserves being produced. Additionally, major company exploration dollars started to flow overseas in the early 1980s as the search for the large hydrocarbon accumulations was diverted to international opportunities. Colorado producers were able to achieve a flat production rate for almost 15 years through careful hydrocarbon reservoir management (secondary and tertiary recovery techniques, new fracture stimulations, recompletions, and infill drilling with improved drilling and completion technologies). However, the failure of Colorado's petroleum industry to make new, large oil field discoveries during the past 15 years has contributed to the decline in oil production that started in 1978 and continues today.

Natural gas has become an increasingly important commodity in both Colorado and the US. In the early 1980s, many 20-year price contracts for natural gas were renegotiated, raising the price of natural gas as much as ten times. During this time, natural gas became touted as a more environmentally friendly energy source and a safer commodity to produce and transport than oil or coal. In just the past five 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.

CBM, as discussed earlier, is a growing resource in the state. The major CBM producing basins include the San Juan and Raton basins. Exploration efforts have commenced recently in the Sand Wash and Piceance Basins. Industry evaluation of CBM potential is being conducted in the North Park and Denver Basins and a joint CGS/Bureau of Land Management project is underway to determine the CBM potential in both the Sand Wash and North and Middle Park Basins in Colorado.

Figures 7 and 8 and Table 1 show the recent impact of CBM production in those active basins in Colorado. In Figure 7, the values for natural gas production include the contributions from CBM since the two gas streams are similar in composition and, in most cases, are priced identically. Figure 8, on the other hand, differentiates between the separate production streams. Production of CBM was first reported separately in the late 1980s, and Figure 8 displays an almost complete historical record of the contributions of CBM production. Before that time, it is likely that the reported values for conventional gas production included small volumes of methane from coals adjacent to sands that were producing natural gas. Natural gas stored in coals is often able to move to overlying and underlying sands through natural vertical fractures, or along induced fractures resulting from completion procedures after wells are drilled.

Table 1 shows a comparison of reserves and production for the top CBM-producing areas in the US from 1989 through 2000. Colorado, New Mexico, and Alabama were the top three producers for a decade. An "others" category includes CBM production from Wyoming, Utah, Oklahoma, West Virginia, Pennsylvania, Virginia, Kansas, and Montana. Wyoming and Utah have recently been removed from the "others" category, joining the top producers group. Wyoming's Powder River Basin has been a hotbed of CBM activity for the past several years; its Paleocene-age Fort Union CBM play is one of the fastest developing gas plays in the US. Beginning ten years ago, Utah has added prolific CBM production from coals within the Cretaceous-age Ferron Sandstone Member of the Mancos Shale in the Uinta Basin.

For the third year in a row, Colorado holds first place in total proved CBM reserves, widening the gap significantly from second place New Mexico which had held the lead in proved CBM

reserves for a decade (Table 1). Colorado's gain in CBM reserves from 2000 to 2001 was 17.6 percent. Colorado continues to be the second-ranked state for CBM production.

Annual production of carbon dioxide (CO_2) has been fairly level, averaging 300 BCF/year since 1986 (Figure 7). Carbon dioxide production fell two percent in 2001 with production of 304 BCF of CO_2 (from 311 in 2000); estimated 2002 production showed an additional three percent drop to 294 BCF. No new reservoirs have been discovered or developed in Colorado in recent years, so there is no new production to replace the gradually depleting reserves. Any future demand for CO_2 floods as a secondary recovery technique in oil reservoirs may prompt a slight increase in production in a given year.

Top County Producers

Thirty-five (or 54 percent) of Colorado's 64 counties produced natural gas including CBM. Figure 13 shows production figures for counties that produce not only natural gas but oil and CO_2 as well. Production figures for gas are preceded by the letter "G" and are reported in thousand cubic feet (MCF).

The rankings for the top three Colorado counties in annual gas production in 2001 were the same as in 2000 (Table 2). La Plata County is still number one in gas production.

The bulk of the natural gas production in 2001 for La Plata County was attributed specifically to CBM production from the Late Cretaceous Fruitland Formation coals of the Ignacio-Blanco field in the San Juan Basin. Figure 14 demonstrates the relative importance of the San Juan Basin CBM production when compared to the total U.S. CBM production. Note that the production in the San Juan Basin appeared to peak in 1999, whereas CBM production from other U.S. basins continues to be increasingly important. Other contributing gas reservoirs in the San Juan Basin include the Dakota and Mesaverde sandstones.

Major reservoirs in Weld County included 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 2001 (Table 2).

In Colorado, 32 of the 64 counties contributed to 2001 oil production (Figure 13). The letter "O" on Figure 13 precedes production volumes for oil. The top three oil-producing counties in 2001, ranked in terms of annual oil production, were Weld, Rio Blanco, and Cheyenne Counties. In addition, these are also the top three counties in terms of cumulative oil production (Table 3).

Weld County continues to be the number one oil producing county, but its total number of permits has more than doubled since 1999 as a result of a major "refracing" effort that began in the Denver Basin in 2000. Weld County oil production is derived predominantly 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 came primarily from the Permo–Pennsylvanian Weber Sandstone in Rangely field. Cheyenne County oil production came primarily from Mississippian and Pennsylvanian-age sandstone and limestone reservoirs.

In terms of carbon dioxide production, Montezuma County contributed 270 BCF—nearly 89 percent of the state's total CO_2 volume in 2001.The Mississippian Leadville Limestone in the county's McElmo Dome field supplies CO_2 that is utilized in secondary recovery efforts in heavy oil reservoirs in the Permian Basin. Dike Mountain and Sheep Mountain fields in the northwestern part of the Raton Basin in Huerfano County produced almost 11 percent of the state's total CO_2. 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 CO_2 production.

Estimated CO_2 production numbers for 2002 are very similar to those for 2001, and are summarized below:

- Montezuma County produced 267 BCF CO_2 worth $107 million (90.5%);
- Huerfano County produced 27 BCF CO_2 worth $10.7 million (9.1%); and
- Jackson County produced 1.1 BCF CO_2 worth $0.4 million (0.4%).

Consumption

An impressive 82 percent of natural gas consumed within the United States is produced in

Table 2. Top three counties for natural gas production for 2001 (COGCC).

RATING	COUNTY	ANNUAL GAS PRODUCTION (MCF)	PERCENT OF ANNUAL COLO. PRODUCTION	CUM. GAS PRODUCTION (MCF)
1	La Plata	424,146,199	51	3,835,183,593
2	Weld	160,334,094	19	2,439,278,306
3	Garfield	86,645,208	11	612,901,827

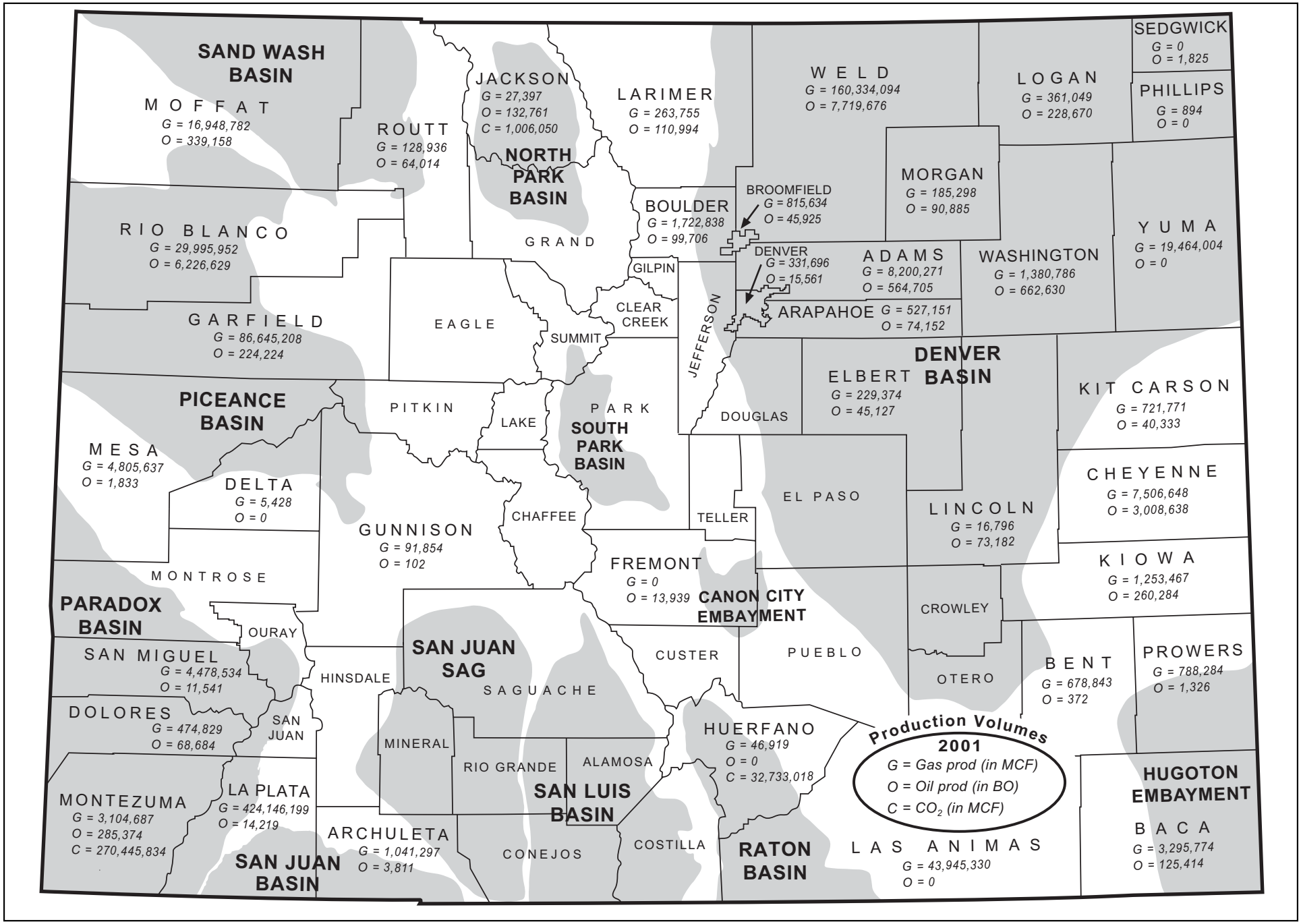


Figure 13. Production volumes for Colorado counties, 2001 (COGCC).

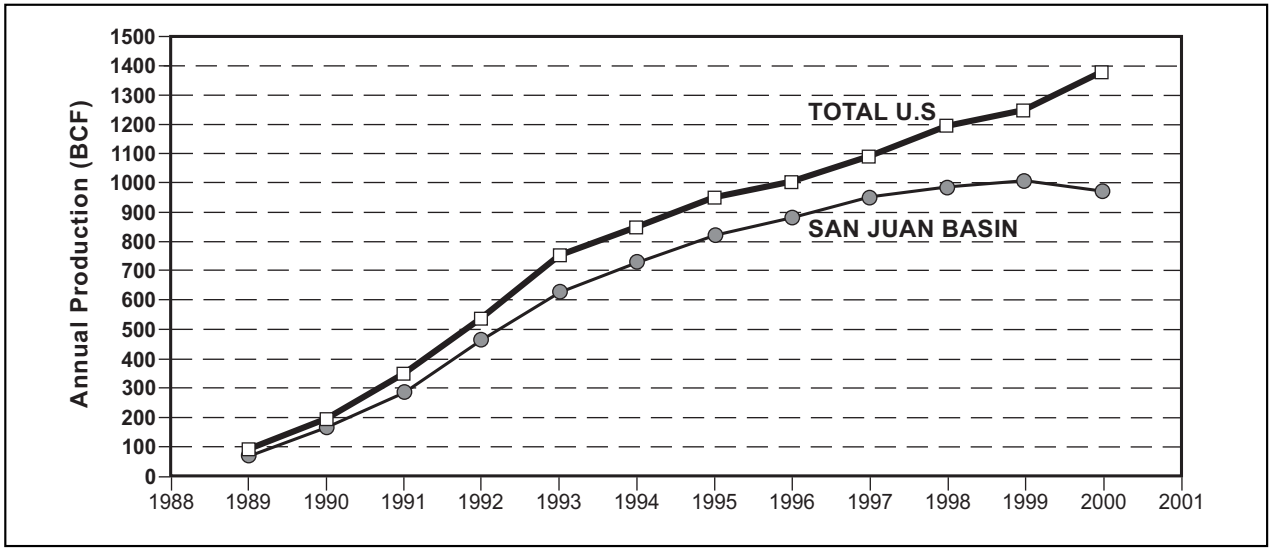


Figure 14. Comparison of annual U.S. coalbed methane production versus the San Juan Basin, Colorado and New Mexico (DOE/EIA and Petoleum Technology Transfer Council-PTTC Regional Review, *San Juan Newsletter*, Oct. 2001).

this country. In contrast, only 42 percent of crude oil consumed in the United States is produced domestically (*Oil & Gas Journal*, Jan. 27, 2003). Gas currently accounts for approximately 17 percent of the total U.S. electrical generation. Colorado's natural gas consumption by sector in 2001 is shown graphically in Figure 15. Colorado has been a net exporter of natural gas since 1991.

Refined crude oil consumption in 2000 is displayed in Figure 16. To see how important both gas and oil are to total energy consumption in Colorado, refer to Figure 17. Clearly the state relies heavily, to the tune of 66.1 percent, on both natural gas and crude oil, for supplying most of the fuels for its total energy consumption.

Commodity Pricing Value and Basis Differential

In 2001, the total value for natural gas (including CBM), crude oil, and carbon dioxide sold in Colorado was $3.51 billion (Table 4)—an all-time high and an increase of 9.2 percent over 2000. The estimated value of these commodities in 2002 is $2.41 billion—a decrease of 45.6 percent from 2001. The extremely high gas prices in early 2001 are the primary reason for the much higher 2001 values.

Monthly average oil and gas wellhead prices from 1998 through 2002, shown in Figure 6, characterize the price volatility that can and does

Table 3. Top three counties for oil production, 2001 (COGCC).

RATING	COUNTY	ANNUAL OIL PRODUCTION (BO)	PERCENT OF ANNUAL COLO. PRODUCTION	CUM. OIL PRODUCTION (BO)
1	Weld	7,719,676	39	197,490,338
2	Rio Blanco	6,226,629	32	941,930,700
3	Garfield	2,008,638	10	80,946,718

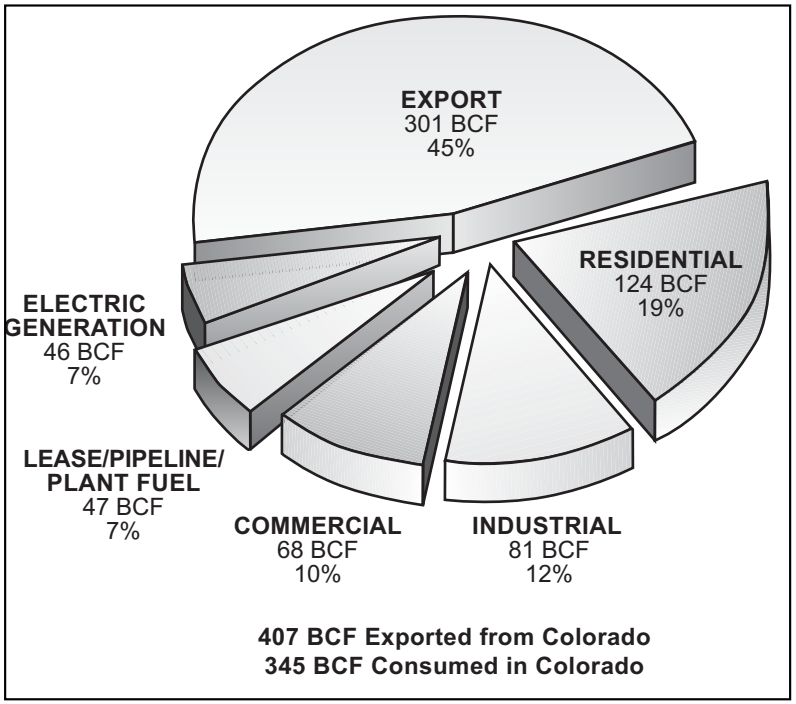


Figure 15. Colorado natural gas consumption by sector, 2001 (DOE/EIA).

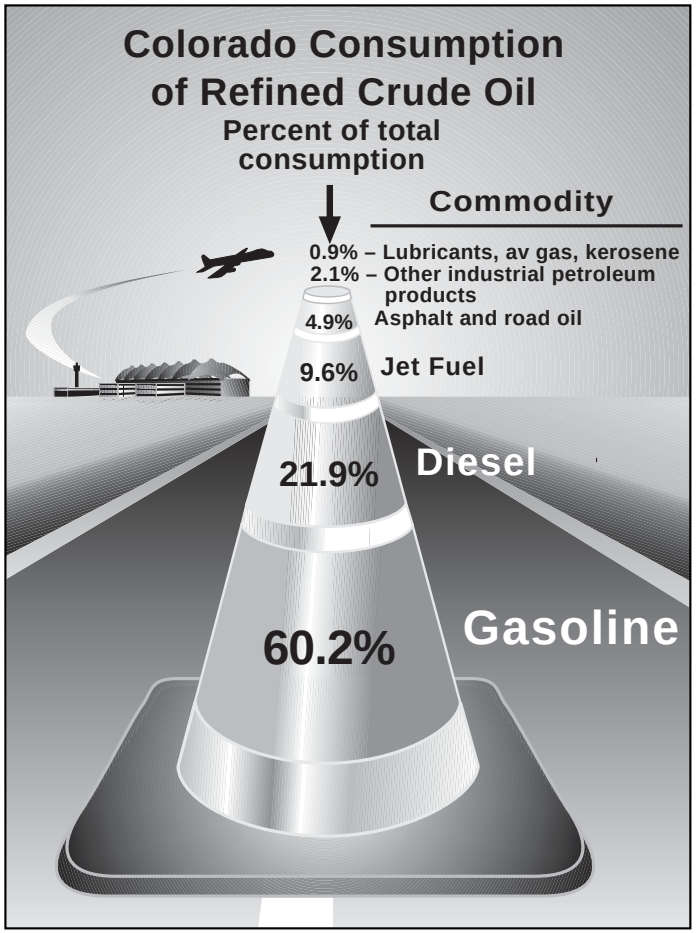


Figure 16. Colorado oil consumption by sector, 2001 (DOE/EIA).

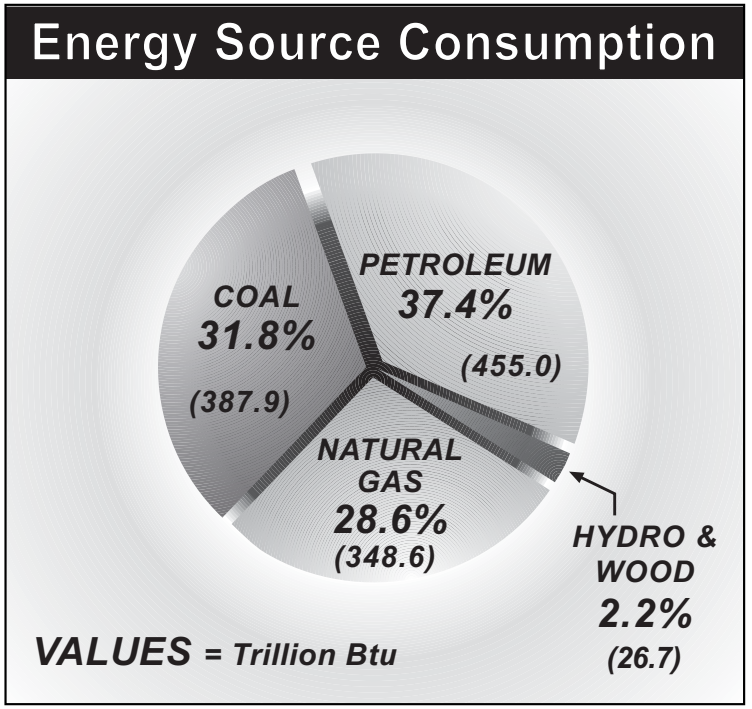


Figure 17. Colorado energy source consumption, 2001 (DOE/EIA).

affect the petroleum industry and its consumers. The wellhead price index for natural gas was extremely volatile during the years 2000 and 2001.

Coupled with this, the basis differential has been steadily widening in 2001 and 2002. The basis differential is the difference between the price of natural gas at the Henry Hub in Louisiana (the largest centralized point for natural gas trading in the United States whose price serves as the benchmark) and the price Colorado operators get for their natural gas. Colorado (and all Rocky Mountain) natural gas producers have historically received a lower price for their gas than do producers in other parts of the country because the pipeline infrastructure to markets in the East and West is insufficient to move the increasing natural gas exports. Producers must compete with each other for pipeline space and accept lower prices to get their gas to market. Basis differentials typically widen during the warmer months when there is less regional demand for natural gas.

The basis differential reached a monthly average maximum in October 2002, at minus $1.85/MMBtu, which equals a price of about $1.96/MCF. Figure 18 shows the Colorado weighted average gas price per month compared with the average Henry Hub price per month. The basis differential is plotted on a separate curve. It is readily apparent that the basis differential has been increasing since mid-2000. The Kern River

Table 4. Value of hydrocarbon commodities from sales in Colorado, 1998–2002 (COGCC).

YEAR	VALUE of NATURAL GAS & CBM (mil $)	VALUE of CRUDE OIL (mil $)	VALUE of CO_2 (mil $)	TOTAL VALUE (mil $)
1998	1,375	285	85	1,745
1999	1,490	334	85	1,909
2000	2,580	537	99	3,216
2001	2,924	466	121	3,512
2002	1,879	414	117	2,411

Table 5. Top five Colorado counties submitting APDs, 1998—2002 (COGCC).

YEAR	Number 1	Number 2	Number 3	Number 4	Number 5	Total APD's
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 (+49%)
2002	760 (Weld)	362 (Garfield)	259 (Las Animas)	160 (Yuma)	105 (Rio Blanco)	2,007 (-12%)

Pipeline with a capacity of 900 MMCF/day will link southwestern Wyoming with markets in California; it is slated to open in May 2003. This will allow more gas to flow to California and should decrease the basis differential, at least temporarily. However, as new gas supplies are discovered in Colorado and other Rocky Mountain states, additional pipeline capacity will be needed or the basis differential will increase.

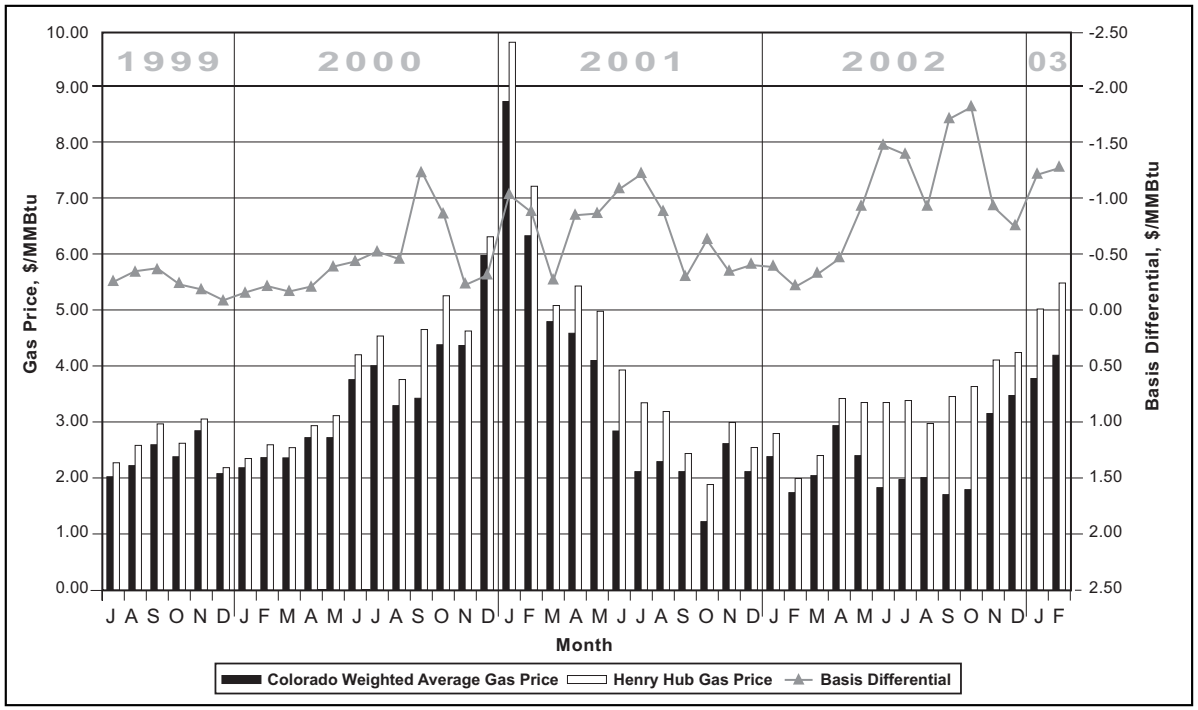


Figure 18. Colorado and Henry Hub gas prices and basis differential (COGCC).

Drilling Permits and Drilling Activity

After two years of growth in the number of drilling permits or "APDs" (Applications for Permit to Drill) in Colorado, the trend changed in 2002. In 2001, APDs rose to 2,273—reflecting the optimism created by high gas prices in early 2001. However, the drop in gas prices and lower oil prices in late 2001 resulted in a drop in the number of APDs in 2002 to a total of 2,007. COGCC projects a similar figure for 2003. Figure 19 shows the number of drilling permits in Colorado for the years 1994 to 2003.

In 2002, the top six counties from which the most APDs were submitted were: Weld County (760), Garfield County (362), Las Animas County (259), Yuma County (160), Rio Blanco County (105), and La Plata County (104) (see Table 5). Figure 20 shows a chart with these 2002 drilling permit statistics. Note that La Plata County, ranked number six on Figure 20, is not included in Table 5 for 2002. La Plata County had been in the top five counties for APDs in other years, but fell to sixth place in 2001.

A brief synopsis of the 2002 activity for each of the five top counties for APDs follows. Activities in Weld County focused upon three procedures: 1) refracs (refracturing an existing producing reservoir utilizing state-of-the-art technologies in an effort to increase production); 2) increased density drilling (adding additional wells in areas where gas and oil is still abundant in the subsurface reservoirs); and 3) deepening existing wells (drilling to a deeper reservoir horizon using the existing well bore). The major hydrocarbon reservoirs in Weld County are the Lower Cretaceous "J" sand, 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 upon the coals of the Mesaverde Group.

Drilling activity in Las Animas County centered exclusively on the Upper Cretaceous 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 CBM development areas in Colorado.

Yuma County, ranked 4th in 2001 and 2002 with 205 and 160 APDs, respectively, showed a large increase from the previous years of only 31 APDs. Upper Cretaceous Niobrara Formation biogenic gas development was responsible for most of this activity.

Finally, the 5th place county for APDs in 2002 was Rio Blanco County where deeper Permo–Pennsylvanian Weber Sandstone permits were joined by permits for shallower Upper Cretaceous Mesaverde Formation sands and coals, sands in the Mancos Shale, and Tertiary Wasatch Formation coals and sands.

A breakdown of wells drilled in Colorado in 2001 and 2002, compared to those drilled in the Rocky Mountain region and in the total United States over that two-year period, is shown on Table 6. All three areas show the

Table 6. Types of wells drilled in Colorado, 2000—2002 (Petroleum Information/Dwights LLC d/b/a IHS Energy Group, 2003).

REGION/YEAR	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)
Colorado–2000	**799**	**65**	**55**	**761**	**761**	**48**	**3**	**864**
Rocky Mtns.–2000	5,564	407	327	5,171	5,171	473	165	5,971
Total U.S.–2000	22,088	2,187	3,697	13,589	13,589	6,989	1,038	24,275
Colorado–2001	**859**	**76**	**80**	**828**	**828**	**27**	**2**	**935**
Rocky Mtns.–2001	6,043	456	302	5,684	5,684	513	216	6,499
Total U.S.–2001	24,503	2,478	3,550	16,257	16,257	7,174	1,009	26,981
Colorado–2002	**1,173**	**40**	**56**	**1,136**	**256**	**21**	**2**	**1,213**
Rocky Mtns.–2002	5,844	342	285	5,143	2,947	402	236	5,830
Total U.S.–2002	20,844	1,869	3,106	14,030	3,417	5,577	877	22,713

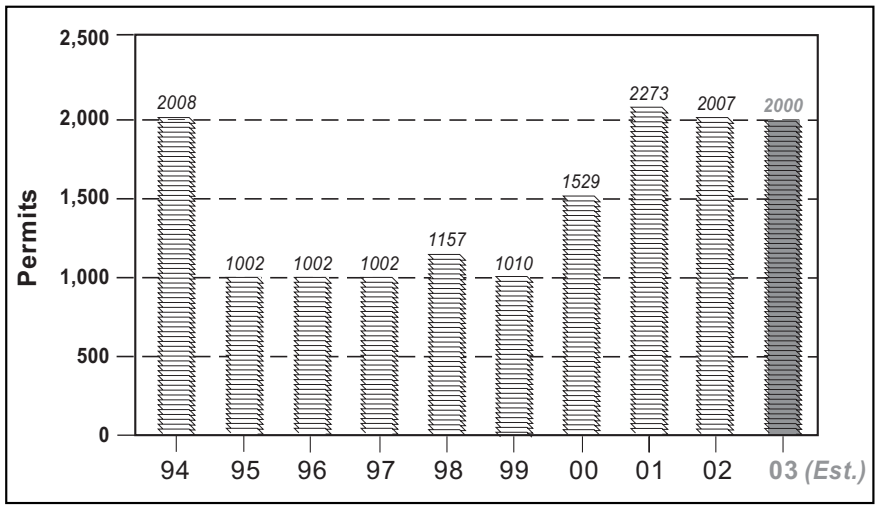


Figure 19. Colorado drilling permits, 1994-2003 (COGCC).

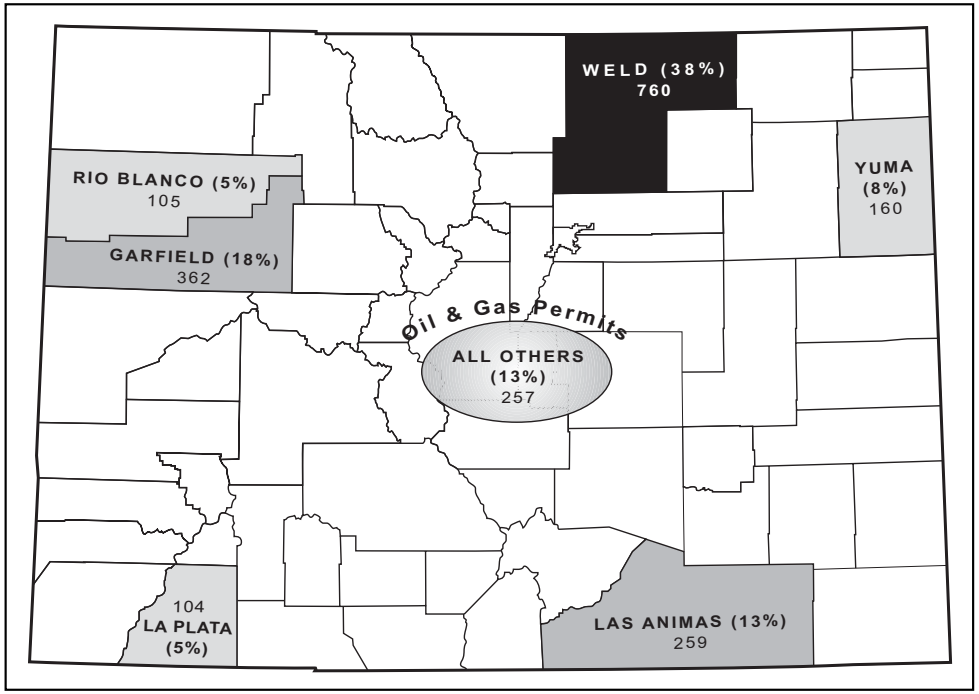


Figure 20. Colorado drilling permits by county (COGCC).

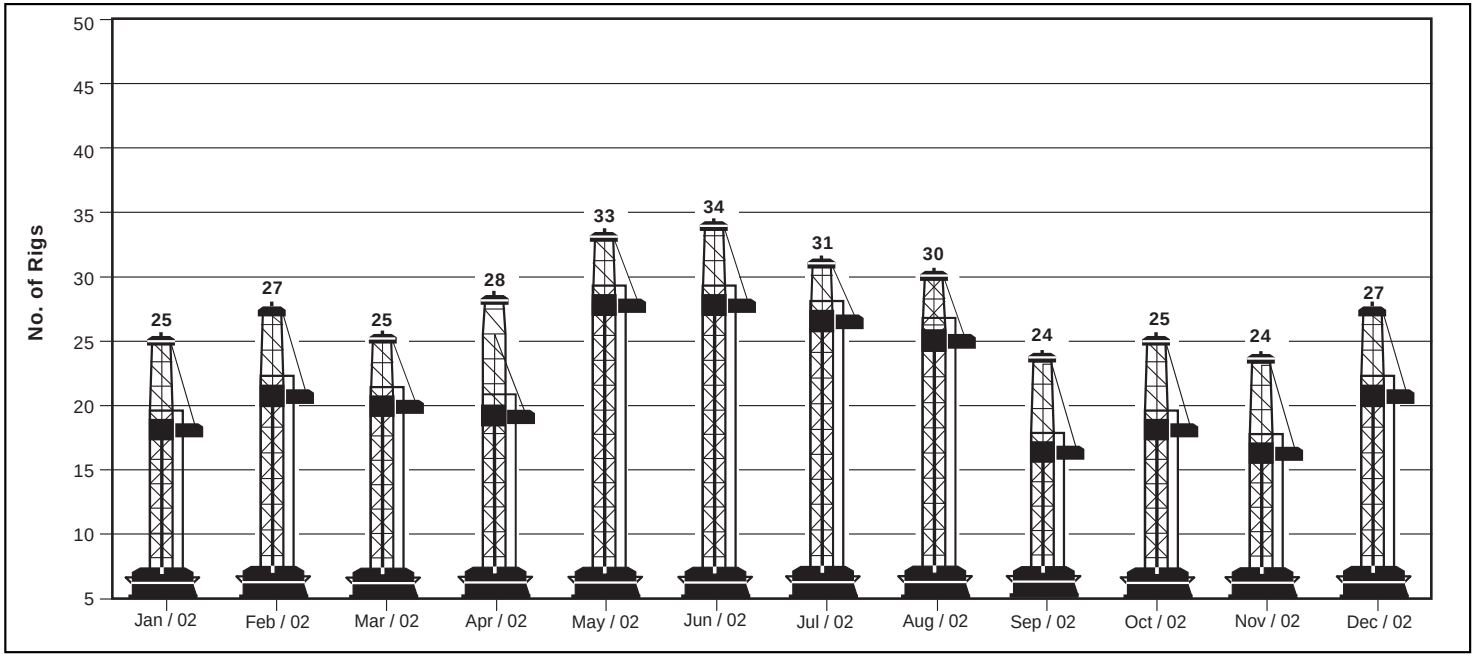


Figure 21. Colorado average monthly drill rig count in 2002 (Baker Hughes, Inc.).

following trends for both 2001 and 2002: 1) development wells exceed exploratory wells by more than an order of magnitude; 2) gas wells drilled greatly exceeded oil wells drilled; 3) Colorado's low percentage of dry holes (nine percent in 2001 and 5 percent in 2002) compared favorably with Rocky Mountain statistics of five percent both years, and was extremely impressive when compared to the national average of 13 percent in both 2001 and 2002 (Petroleum Information/Dwights LLC d\b\a IHS Energy Group, 2003).

Active rotary rig count for the total United States averaged 830 in 2002, down 28 percent from the average of 1,156 in 2001. The average number of rigs in Colorado was 28, down from 32 in 2001—a 14 percent decrease. (*Oil & Gas Journal*, Jan. 27, 2003, p. 76)—these Colorado monthly rig-count figures are displayed in Figure 21. Note the similarity of Colorado's 2002 rig count Figure 21 and the 2002 U.S. rig count in Figure 22.

In February 2003, Colorado had 23,995 active wells. Figure 23 shows the distribution of those active wells among the top seven counties in the state. Weld County is well ahead of all other counties with 9,765 active wells (41 percent) followed by La Plata County with 2,461 wells (10 percent) a distant second.

Employment Statistics

The Colorado Department of Labor and Employment projected approximately 7,772 jobs in 2001 for the oil and gas extraction sector of the petroleum industry in Colorado—a

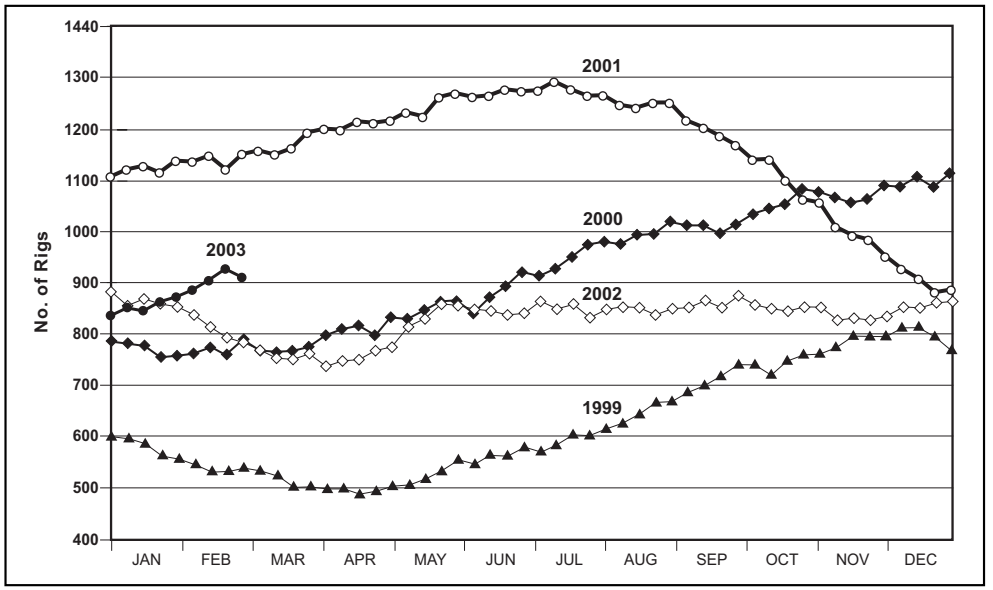


Figure 22. U.S. average drill rig count (Baker Hughes).

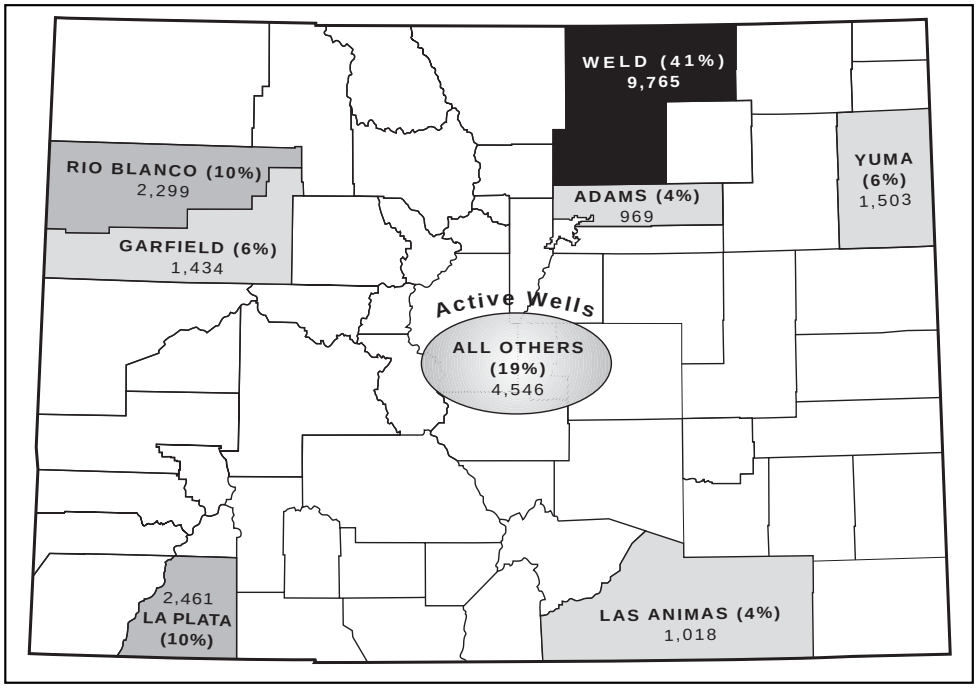


Figure 23. Active wells in Colorado counties (COGCC).

U.S. natural gas, the Rocky Mountain region contains 29 percent of those reserves (Figure 24). Figure 25 illustrates the significance of the potential gas resources attributed to the Rocky Mountain region compared to the other major U.S. regions. The fact that Rocky Mountain reservoirs are underexplored and underdeveloped, while Gulf Coast and Mid-Continent reservoirs are, for the most part, well developed and exhibit declining production, explains the industry's fascination with the Rocky Mountain states including Colorado.

Proved crude oil reserves in Colorado were 196 MMBO at the end of 2001—'down 9.6 percent from the 2000 total of 217 MMBO (U.S. DOE/EIA: U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves *2001 Annual Report*, p. 22). Colorado's crude oil reserves constituted slightly less than 12 percent of the total reserves in the Rocky Mountain region

decrease of about 79 jobs from 2000. Their estimate for jobs in 2002 is 8,157—an increase of 385 (an increase 5 percent).

Reserves

Colorado

Proved dry natural gas reserves in Colorado were estimated at 12,527 BCF at the end of 2001—a 20 percent increase from the 2000 total of 10,428 BCF (U.S. DOE/EIA: U. S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2001 Annual Report, p. 30). This volume accounts for 23.7 percent of the Rocky Mountain region's (Colorado, New Mexico, Utah, and Wyoming) proved gas reserves of 52.9 TCF. Colorado is ranked fifth in the United States in proved dry natural gas reserves. Of the approximate 183 TCF of proved reserves for

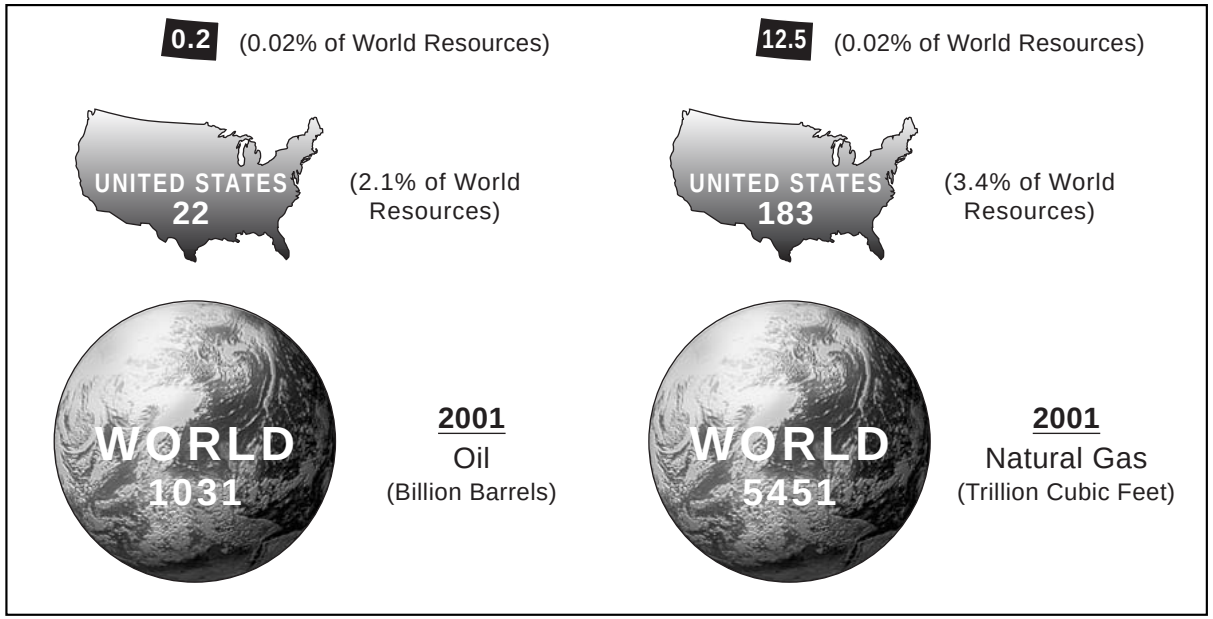


Figure 24. Total U.S. natural gas and oil proven reserves (DOE/EIA).

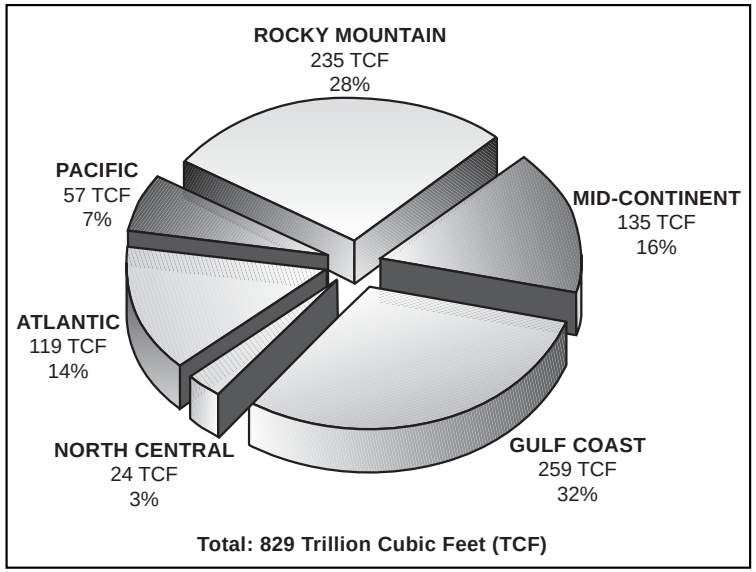


Figure 25. Estimate of potential natural gas reserves (DOE/EIA).

and less than 1 percent of the nation's proved crude oil reserves of 22,446 MMBO at the end of 2001. Colorado was ranked 11th among the states in proved crude oil reserves in 2001.

United States

In December 2001, the U.S. proved reserves of dry natural gas were 183,460 BCF (183 TCF)—a 3.4 percent increase from the December 2000 total of 177,427 BCF (U.S. DOE/EIA: U. S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves *2001 Annual Report*, p. 30). The U.S. total discoveries of dry natural gas were up 3,578 BCF in 2001.

Year-end 2001 U.S. proved reserves of crude oil were 22.45 billion barrels of oil (BBO), a 1.8 percent increase from 22.05 BBO in 2000. In the United States, crude oil production was replaced 121 percent by the identification of new reserves (U.S. DOE/EIA: U. S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves *2001 Annual Report*, p. 21–22).

World

World gas reserves in 2002 grew to 5,451 TCF—up 3.3 percent from the published 2001 world gas reserves of 5,278 TCF (*Oil and Gas Journal*, Dec. 23, 2002). World oil reserves climbed to 1.031 trillion barrels in 2002—"up 1 percent from the 2001 world oil reserves of 1.028 trillion barrels. The projections for world oil reserves are estimated to be 1.213 trillion barrels in 2003—a whopping 17.7 percent increase over 2002 proved oil reserves. The reason for this huge increase is the inclusion of Alberta's oil sands; it is thought that they contain 174.8 billion barrels of bitumen. By adding these reserves, OPEC's share of world oil reserves dropped to 67.5 percent of all crude and condensate reserves (from 79.4 percent a year ago) and 45 percent of the world's natural gas reserves—compared to 46 percent a year ago (*Oil and Gas Journal*, Dec. 23, 2002, p. 113).

Forecasts

Natural gas prices were on the rise in the fourth quarter of 2002 and continue to rise in the first quarter of 2003 probably because of the cold winter the eastern United States has experienced. Oil prices are also rising, and may continue to rise as a result of supply disruptions due to the war in Iraq.

The COGCC estimates the production value of oil, gas, and CO_2 will be $3 billion in 2003—a 21 percent increase from 2002. They forecast average natural gas prices of $4.16/MMBtu in 2003—an 82 percent increase over the 2002 average of $2.29/MMBtu, with the basis differential increasing to $1.40/MMBtu. They also predict that daily average oil production will remain flat with 2002 rates, but the average oil price will rise to $28.66/barrel in 2003—an increase of 22 percent from the average 2002 price of $23.52. However, the war in Iraq and the continuing struggling economy make forecasts very uncertain.

The DOE/EIA forecasts increasing oil and natural gas demand in the United States in 2003 and 2004 as the economy recovers. It forecasts a 2.9 percent growth in the economy in 2003. They also forecast rising prices for both years. Natural gas prices are rising because of a colder-than-normal winter in the northeastern United States which has reduced natural gas stocks below their previous minimum in 2001 when gas prices soared. Wellhead natural gas prices are expected to average $4.80/MCF in 2003, and could become volatile if demand spikes. EIA forecasts a 3.7 percent growth in natural gas demand in 2003 and a continued rise in 2004, while natural gas production increases only 1.2 percent in 2003.

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 (the Venezuelan general strike has ended, but the strike against the oil sector continues as of this writing in March 2003). OPEC production has been increasing since December to offset disruptions in Iraq and Venezuela. U.S. oil demand is expected to grow by 500,000 barrels/day in 2003 while domestic oil production will decrease by 60,000 barrels/day.

The petroleum industry, and particularly the natural gas sector in Colorado may be poised for another boom. High natural gas prices and soaring oil and gas field revenues are expected to drive a resurgence in natural gas-directed activity this year following a downturn in 2002. (DOE/EIA Short Term Energy Outlook, March 6, 2003 Release).

GLOSSARY

(A)	Acquisition
APD	Application for permit to drill
Bbl	Barrel (of oil)
BBO	Bllion 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 SITES

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/fs/miner
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/statistics
Department of Energy (DOE)	energy.gov/sources
DOE/Energy Information Administration (EIA)	eia.doe.gov
Edison Electric Institute (EEI)	eei.org
Gas Research Institute (GRI)	gri.org
Independent Petroleum Association of America (IPAA)	ipaa.org
Independent Petroleum Association of Mountain States (IPAMS)	ipams.org
Institute of Gas Technology (IGT)	igt.org
Interstate Natural Gas Association of America (INGAA)	ingaa.org
Montana Petroleum Association	montanapetroleum.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/stats

COAL

By Christopher J. Carroll

INTRODUCTION

The Colorado coal industry continues on its path of success. For the fifth time in six years (Figure 26) Colorado coal mines broke the annual coal production record. In 2002, more than 35.2 million short tons of coal were produced from 12 coal mines—a five percent increase over the previous year. Colorado's saleable coal product has now more than doubled since 1989. The coal industry is proving to be a stable economic factor of the state's economy. Increased production also means new exploration and development, providing jobs to peripheral industries in the coal community. The coal mines are located in rural areas of western Colorado and provide a stable base for employment. Colorado is ranked eighth in U.S. coal production.

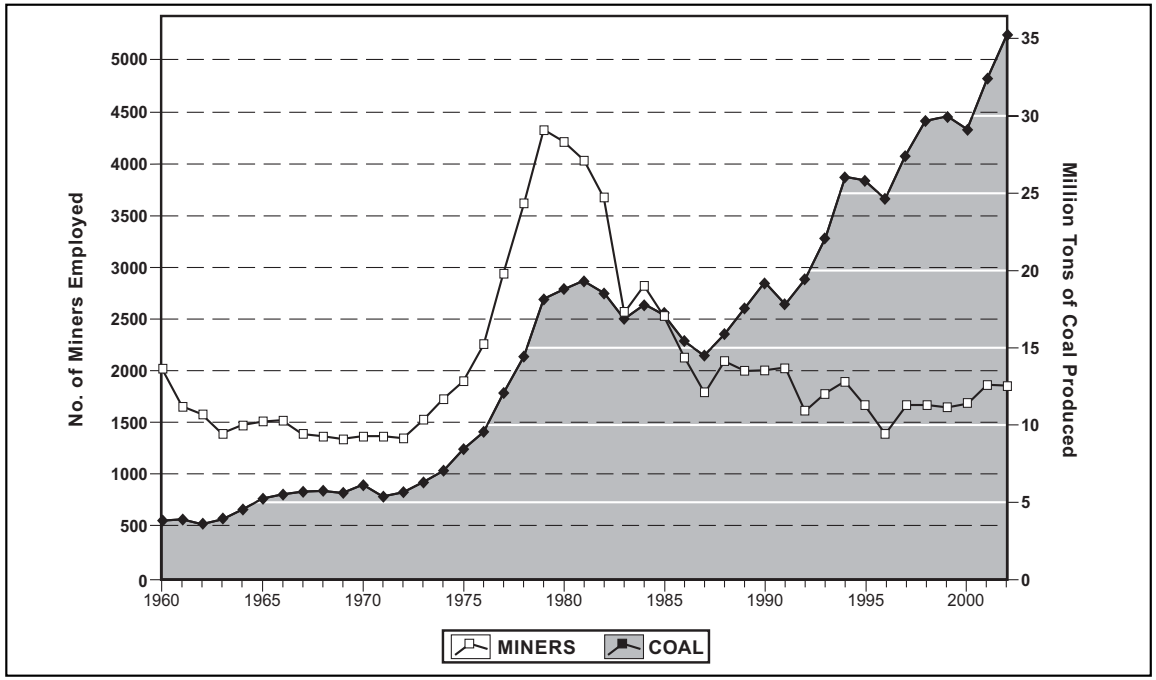


Figure 26. Colorado coal production and employment, 1960—2002 (Colorado Division of Minerals and Geology [CDMG]).

As the U.S. population and its demand for electricity grows, so does coal consumption. According to Jack Gerard, President of the National Mining Association (NMA), "the use of coal for electric power has seen a 179 percent increase in electric generation to meet a 142 percent national increase in demand for power since 1970. As the percentage of coal-based power increases, environmental pollution has dropped 30 percent in terms of total sulfur dioxide emissions, and a 71 percent decrease in sulfur emissions per kilowatt-hour of power produced." Environmentally-compliant Colorado coal is an important factor in this equation.

Every sector of the coal industry saw increases in 2002. There were 1,853 miners were employed at Colorado mines as of December 2002—a 3 percent increase over the previous year. The price of coal peaked in late 2001 and has remained high at or slightly under $17.50/ton average at the mines. The value of coal produced in 2002 is estimated at $616 million.

Nearly 95 percent of Colorado coal sales were completed on the open market last year. Colorado's coal sales market follows closely with the sale of Wyoming's Powder River Basin coal. Wyoming captures the national coal market by selling inexpensive, low sulfur coal. Colorado coal also sells well as a low-sulfur, but higher heat value blended coal to similar customers in the midwestern United States. Coal production in central Appalachia and the Illinois Basin is declining due to increased use of low-sulfur western-U.S. coals, and the exhaustion of thick, mineable seams. On the national level, coal is expected to increase its share of the electrical generation market because of increasing natural gas prices, a flat market for renewable energies, and recent security worries about the hydroelectric and nuclear power industries. Coal is the lowest cost fuel for electrical generation in America.

The U.S. Department of Energy's Energy Information Administration (EIA) forecasts the national average mine mouth price of coal to decline from $17.59 in 2001 to about $14.40 per short ton (2001 dollars) in 2020, and remain at about that level through 2025. Price declines are expected because of increased mine productivity, a shift to cheaper western U.S. coal production, and competitive pressures on labor costs.

2002 COAL SUPPLY

In addition to the new state coal production record, several mines also set individual production records in 2002. Eight mines each

surpassed their own annual output records: Bowie No. 2, Deserado, King Coal, Lorencito Canyon, McClane Canyon, Sanborn Creek, the Seneca Strip Mines, and West Elk Mines (Table 7). A combination of high demand, favorable mining conditions, no major work stoppages and high prices enabled this record production. A record 25,483,668 short tons of coal were produced from seven underground mines and 9,720,040 short tons from five surface mines (see Figure 27 for mine locations). Most of this coal was bituminous; only two mines produced subbituminous products (Trapper and Colowyo). According to EIA (2001), RAG-American's Foidel Creek Mine ranks nationally as the twentieth largest coal mine and the third largest underground coal mine. Kennecott's Colowyo Mine, the largest surface mine in Colorado, is the nation's 33rd largest coal mine and the 25th largest surface mine. It is interesting to note that the top 12 coal mines are large surface mines located in Wyoming, North Dakota, and Montana where shallow coal seams can reach 100 feet thick.

Coal was produced in nine Colorado counties last year. For the first time in many years Routt County was replaced as the state's top coal producing county. Gunnison County was the state's leading coal producing county at 9.7 million short tons in 2002 (Figure 28). The county's two mines, Sanborn Creek and West Elk, both maximized their respective productive capacities throughout the year.

The three highest coal-producing counties were (in order) Gunnison, Routt, and Moffat counties accounting for 75 percent of the state's coal production. With regard to geologic coal regions, the large Uinta coal region was the leading producer with nearly 23 million short tons from six mines (Table 8). Somerset was the most prolific coal field (Bowie No. 2, West Elk, and Sanborn Creek Mines) at 15,165,425 short tons produced.

Coal sales slowed slightly at the end of 2002 as prices softened. Some mines report excess stockpiles, although mostly due to major longwall moves in March 2003 (West Elk and Sanborn Creek-New Elk Mines). As of March 22, 2003, Colorado coal production is down ten percent over the same time a year ago. However, colder weather in the eastern United States in the past year has increased the short-term need for coal at electric power plants. In much of the country, November and December 2002 were colder than in 2001, and in Colorado, March 2003

Table 7. Colorado coal mining statistics, 2002 (CDMG). Mine numbers correspond to locations in Figure 27.

MINE NO.	MINE NAME	COUNTY	COAL REGION	COAL FIELD	OPERATOR	TWNSHP./ RANGE	GEOLOGIC FORMATION	PRODUCING BED NAMES	SEAM THICKNESS (ft)	BTU AVERAGE	MINE TYPE	MINING METHOD	2002 PROD (tons)	DECEMBER 2002 MINERS	SHIPMENT METHOD
1	Bowie #2	Delta	Uinta	Somerset	Bowie Resources, Ltd.	13S, 91W	Mesaverde	D	9 – 12	11,800	U	Longwall, continuous	5,396,329	209	Truck, rail
2	Lorencito Canyon	Las Animas	Raton Mesa	Trinidad	Lorencito Coal, Llc.	34S, 66W	Raton	Na, M	1.5 – 4	13,000	S	Contour-shovels, dozers	154,824	10	Rail
3	West Elk	Gunnison	Uinta	Somerset	Mountain Coal Co.	13S, 90W	Mesaverde	B	14	11,650	U	Longwall, continuous	6,560,421	286	Rail
4	Sanborn Creek	Gunnison	Uinta	Somerset	Oxbow Mining, Inc.	13S, 90W	Mesaverde	B, C	B18–25; C6 – 8	12,375	U	Longwall, continuous	3,208,675	270	Rail
5	King Coal	La Plata	San Juan River	Durango	National King Coal, LLC	35N, 11W	Upper Menefee	Upper Bed	4.3 – 6	12,500	U	Continuous	328,730	56	Truck
6	McClane Canyon	Garfield	Uinta	Book Cliffs	Lodestar	7S, 102W	Mesaverde	Cameo B	4.4 – 9.4	11,250	U	Continuous	327,199	22	Truck
7	Colowyo	Moffat	Uinta	Danforth Hills	Colowyo Coal Co. (Kennecot)	4N, 93W	Williams Fork – Fairfield Coal Grp.	A – F, X, Y	8 beds 5.4 – 10.7	10,453	S	Dragline, shovels, dozers	5,348,412	256	Rail
8	Trapper	Moffat	Green River	Yampa	Trapper Mining, Inc.	6N, 90W	Williams Fork – Upper Coal Grp.	H, I, L, Q, R	6, 5, 4, 13, 4	9,850	S	Dragline, shovels, hyd. excav.	2,038,099	120	Truck
9	New Horizon	Montrose	San Juan River	Nucla–Naturita	Western Fuels Association	46N, 15W	Dakota	1, 2	0.75 – 1.25 4.0 – 6.5	10,800	S	Shovels, dozers	386,366	23	Truck
10	Deserado	Rio Blanco	Uinta	Lower White River	Blue Mountain Energy, Inc.	3N, 101W	Williams Fork	B Seam	7.0 – 16.0	10,000	U	Longwall, continuous	2,088,876	169	Rail
11	Twentymile (Foidel Creek)	Routt	Green River	Yampa	Twentymile Coal Co. (RAG American Coal)	5N, 86W	Williams Fork – Mid. Coal Grp.	Wadge	7.0 – 11.0	11,250	U	Longwall, continuous	7,573,438	328	Rail
12	Seneca II-W, Yoast	Routt	Green River	Yampa	Peabody Western Coal Co.	5N, 87W	Williams Fork – Mid. Coal Grp.	Wadge, Wolf Crk., Sage Crk.	8.9 – 14.2, 15 – 20.4, 3.4 – 5.4	11,908 – 12,581	S	Dragline, loaders	1,792,339	104	Truck, rail
TOTAL													**35,203,708**	**1,853**	

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

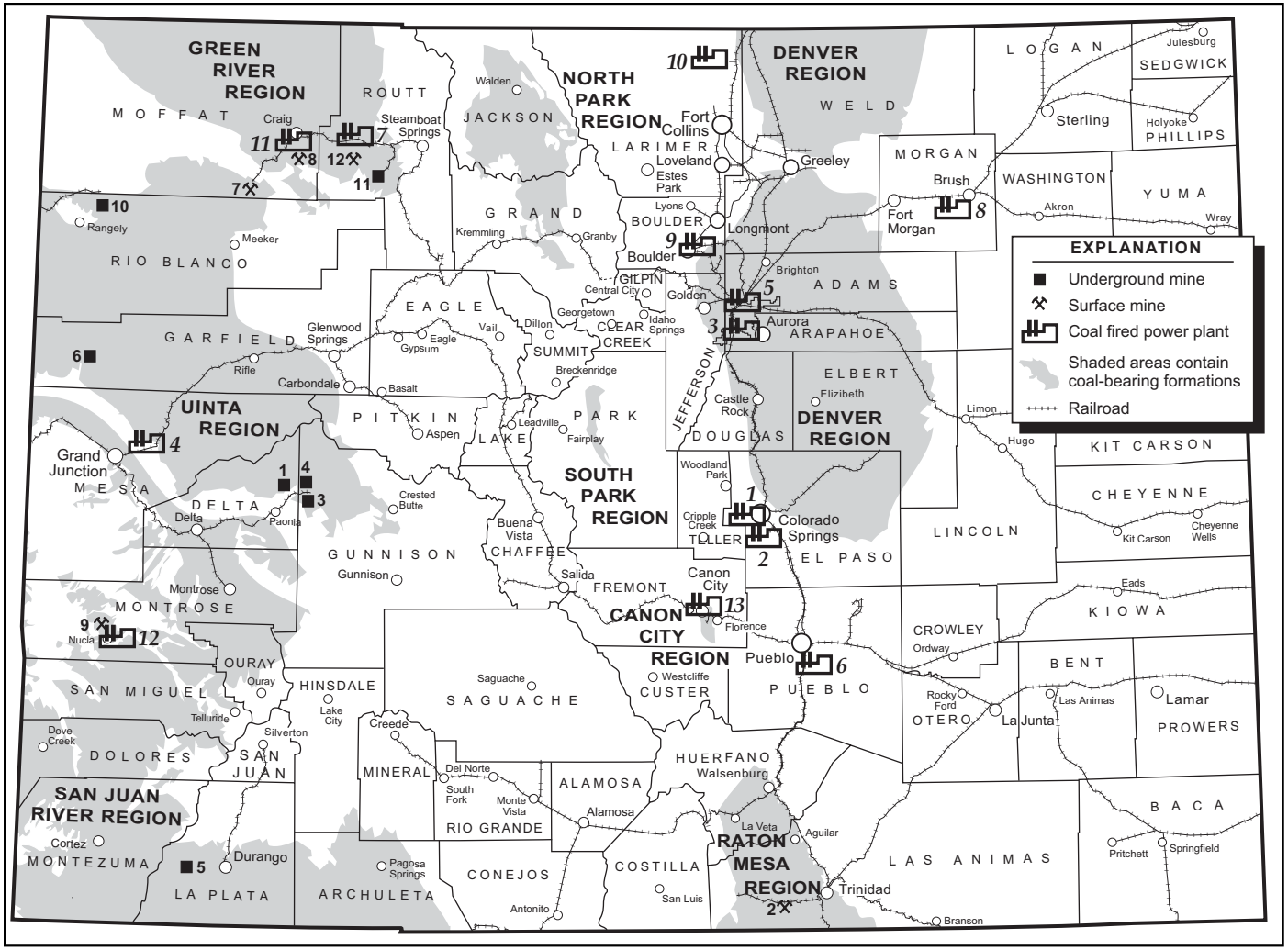


Figure 27. Colorado coal regions. See Table 7 for mine names, and Table 10 for plant names.

was much colder. Although U.S. coal production was down slightly in 2002, national electricity net generation was 2 percent greater in 2002 than in 2001. (EIA Electric Power Monthly, Feb. 2003).

Distribution and Consumption

The main distribution method for coal in the West is rail. Union Pacific Railroad is the largest coal transporter from western Colorado to the Front Range. Some Colorado mines haul coal by truck, such as King Coal, McClane Canyon, New Horizon, Trapper, and the Seneca Mines. 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

Table 8. Colorado coal production, employment, and mines listed by coal region, 2002 (CDMG).

COAL REGION	PRODUCTION (short tons)	NUMBER of MINERS (December 2002)	NUMBER of MINES (Surface / Underground)	MINES
Green River	11,403,876	552	2/1	Foidel Creek, Seneca (Seneca II-W and Yoast), Trapper
Raton Mesa	154,824	10	1/0	Lorencito Canyon
San Juan River	715,096	79	1/1	King Coal, New Horizon
Uinta	22,929,912	1,212	1/5	Colowyo, McClane Canyon, Deserado, Bowie No. 2, Sanborn Creek, West Elk
Total	35,203,708	1,853	5/7	

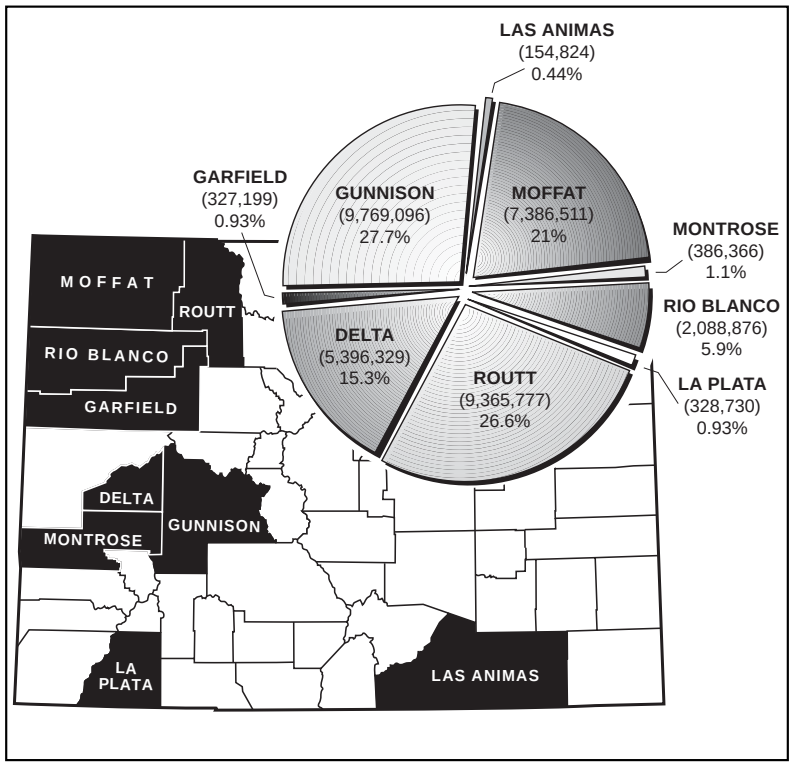


Figure 28. Colorado coal production by county, 2002 (CDMG). Production is shown in short tons and percentage of state total.

91 percent of the coal mined in Colorado is used for electricity generation, 9 percent for industrial plants, and less than 1 percent for coking, residential, and commercial use. Only King Coal in La Plata County transports coal by truck to out-of-state customers for cement manufacturing. Of the coal mines that use rail transportation, only the Deserado Mine in Rio Blanco County supplies mine-mouth coal to a power plant operation outside of Colorado.

About half of the coal produced in-state is burned at Colorado power plants. Most coal is shipped to midwestern states and burned at power plants as compliance coal to lower total sulfur content. According to EIA the leading Colorado coal exports were to Kentucky, Texas,

Table 9. Distribution of Colorado coal, 2001 (DOE/EIA). All units shown in thousands of short tons.

STATE OF DESTINATION	ELECTRIC UTILITIES (steam coal)	COKE PLANTS	INDUSTRIAL PLANTS	RESIDENTIAL/ COMMERCIAL	TOTAL
Arizona	987	0	107	0	1,094
Arkansas	0	0	124	0	124
California	9	0	0	0	9
Colorado (In-state)	11,044	0	349	281	11,674
Georgia	49	0	0	0	49
Illinois	1,579	0	67	0	1,646
Indiana	0	0	191	0	191
Iowa	486	0	174	0	660
Kansas	1,384	0	77	0	1,461
Kentucky	4,229	0	0	0	4,229
Michigan	975	0	198	0	1,173
Mississippi	1,773	0	0	0	1,773
Missouri	274	0	152	0	426
Nebraska	0	0	156	0	162
New Mexico	0	0	72	0	72
Ohio	25	0	0	0	25
Tennessee	1,479	0	0	0	1,479
Texas	1,550	0	684	0	2,234
Utah	2,078	0	0	0	2,177
Wisconsin	1,605	0	0	0	1,605
Wyoming	0	0	159	0	159
TOTAL DOMESTIC	29,526	99	2,510	287	32,422
Japan	894	0	0	0	894
TOTAL DOMESTIC/ FOREIGN EXPORT	30,420	99	2,510	287	33,316

Utah, Mississippi, and Illinois in 2001 (Table 9). Most of this coal is used as steam coal, but some is shipped for coke (Utah), and industrial uses (mostly in Texas). Most Colorado coal moved east via rail, and some even traveled along interior waterways in the Midwest and Great Lakes regions.

About 21.2 million short tons of coal were shipped to destinations within Colorado in 2001 (EIA, 2001). Colorado imports coal 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 (PRB) coal. Statewide, 10.2 million short tons of steam coal were shipped from Wyoming to Colorado in 2001. In addition, some 20,000 short tons of anthracite were shipped from Pennsylvania for industrial purposes (EIA, 2001). A total of 19.1 million tons of coal were consumed at coal-fired power plants in Colorado in 2002 (Table 10)—a 4 percent decrease from 2001. Figure 29 depicts a flow diagram of coal distribution and consumption in Colorado.

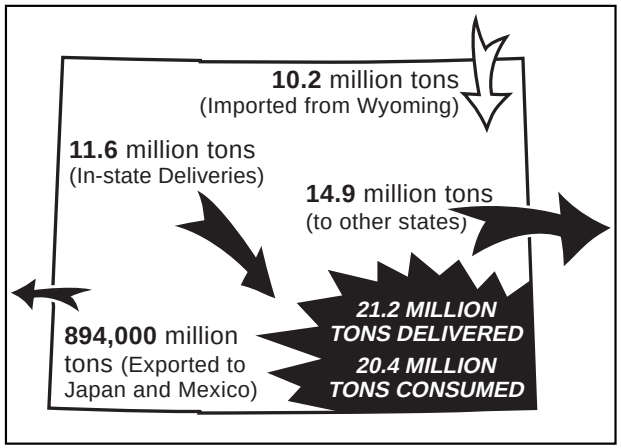


Figure 29. Diagram of the distribution and consumption of coal in Colorado (EIA, 2001). Includes electric power, industrial, and commercial coal.

Table 10. Consumption of coal at electric generation plants in Colorado, 2002. Plant number corresponds to location in Figure 27. Source of data from utility companies, 2003.

MAP NO.	PLANT NAME	UTILITY	LOCATION	20012 COAL COMSUMPTION (short tons)	ORIGINATION of COAL
1	Drake	Colorado Springs Utilities	Colorado Springs	886,544	80% Foidel Cr., 20% Wyo. PRB
2	Nixon	Colorado Springs Utilities	Fountain	969,746	Wyoming PRB
3	Arapahoe	Xcel Energy	Denver	905,401	Wyoming PRB
4	Cameo	Xcel Energy	Palisade	308,369	McClane Canyon Mine
5	Cherokee	Xcel Energy	Denver	2,067,822	99% Foidel Creek, 1% Colowyo
6	Comanche	Xcel Energy	Pueblo	2,875,493	Wyoming PRB
7	Hayden	Xcel Energy	Hayden	1,808,105	Seneca Mines
8	Pawnee	Xcel Energy	Pawnee/Brush	2,068,975	Wyoming PRB
9	Valmont	Xcel Energy	Boulder	551,804	69% Foidel Creek, 31% Colowyo
10	Rawhide	Platte River Power Authority	Wellington	1,199,505	Wyoming PRB
11	Craig	Tri-State G & T Association	Craig	4,967,033	58% Colowyo, 42% Trapper
12	Nucla	Tri-State G & T Association	Nucla	381,095	New Horizon Mine
13	Clark	Utilicorp	Canon City	151,292	Foidel Creek Mine
STATE TOTAL				19,141,184	

PRB = Powder River Basin

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 2002 the plant consumed 4.97 million short tons of Colorado coal. The station receives its fuel from two surface mines—Trapper Mine and Colowyo Mine. Nationally, Tri-State ranks 47th for coal consumption with coal-fired power plants in Colorado and New Mexico.

Power plant engineers at Colorado Springs Utilities report that PRB coal requires a blended mixture because of the low heat value and lower ash fusion temperatures. The lower rank coal creates a slag in the boilers. They mix a blended coal of 80 percent Wyoming coal to 20 percent Colorado coal to help increase the burning temperature, which helps decrease the amount of slag.

The net electrical grid in Colorado is dominated by coal fuel sources (Figure 30). Coal (85 percent) and natural gas make up most of the Colorado fuel sources, with petroleum, hydroelectric, and wind energy far behind. Renewable energies in Colorado lag somewhat compared to national standards, due to the cheap local sources of coal and gas. On the national

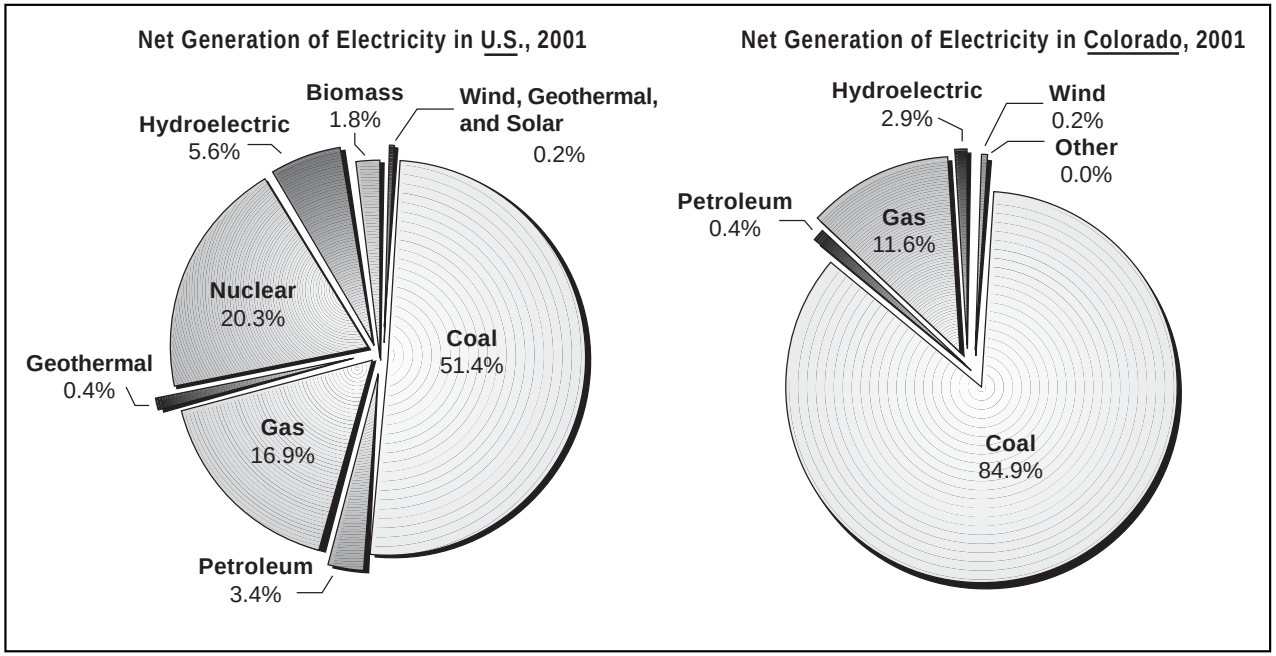


Figure 30. Pie charts comparing Colorado electricity generation by fuel type to the national perspective, 2001(DOE/EIA and Xcel Energy).

level, the picture is quite different, as coal only has a 51 percent share of the electrical generation market, followed by 20 percent from nuclear, 17 percent from gas, 5.6 percent from hydroelectric, 3.4 percent from petroleum, and 2 percent from renewable sources. United States demand for coal consumption is forecasted to increase by one or two percent annually for the next three years (EIA Short-Term Energy Outlook, Mar. 2003). However, for the first 11 months of 2002 national energy consumption was down 2 percent from the previous year.

Employment and Productivity

Gunnison County has the most miners employed with 556 in December 2002. Much of this is due to Oxbow Mining'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 miners produced 8.43 short tons of coal per miner-hour in 2001 (EIA 2001 data)—a 10 percent increase over 2000. In terms of the type of mining, underground miners in Colorado produced at a rate of 8.58 short tons per miner-hour (the second highest productivity in the nation after Utah's 9.03 short tons per miner-hour). Colorado surface mining productivity was 8.09 short tons per miner-hour—a 9 percent increase over 2000. Approximately 41 percent of the coal miners in the state are union workers who provided 44 percent of the coal mined in the state in 2001 (EIA, 2001 data). Labor productivity is expected to increase 2.3 percent per year for the next 17 years, according to EIA (2003 Forecast).

Productive capacity is the maximum amount of coal that can be produced annually. Colorado has 41.6 million short tons of productive capacity (EIA 2001 data), which is comparable to the previous year. EIA defines capacity utilization as the ratio of total production to annual productive capacity. In terms of capacity utilization, Colorado produced 81 percent of its potential in 2001 (EIA 2001)—an 11 percent increase in one year. This increase is attributed to the increase in underground mining, which changed from 62.8 percent in 2000 to 76.4 percent capacity utilization in 2001. Surface mines utilized 94 percent of their capacity. At these very high rates of productivity, coal production in Colorado is projected to remain at its current level unless the number of mines increase. U.S. coal production is projected to increase from 1,138 million short tons in 2001 to 1,440 million short tons by 2025—an average rate of 1 percent per year.

The 2002 Longwall Census from *Coal Age* magazine reports five active longwall machines in Colorado (Table 11). These are Arch 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. Four of these mines (West Elk, Deserado, Bowie No. 2, and Sanborn Creek) set both monthly and annual coal production records in 2002.

Nationally, 48 mines operate 52 longwall faces (*Coal Age*, Feb. 2003). CONSOL Energy remains the industry leader with a dozen longwall faces, none of which are in Colorado. Arch Coal has five, and Massey Energy has four. West Virginia has the most faces (12), followed by Pennsylvania (8), and Alabama (7) (*Coal Age,* Feb. 2003). Since their invention longwalls have grown steadily in physical size and power. The average U.S. longwall has an 86-inch-cutting height, a 924-foot-wide face, a

Table 11. Colorado longwall mining statistics.

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 #2)	D	108 – 180	120	845	7,000	800 – 1,400	36	DBT America DDR 1,300
Blue Mtn. Energy (Deserado)	B	84 – 180	132	800	6,000	240 – 1,800	32	Joy 4LS-5 DDR 1,030
Oxbow Mining (Sanborn Creek)	B	180	132	580	4,400	1,500 – 2,500	30	Joy 4LS-5 DDR 1,030
RAG American Coal (Foidel Creek)	Wadge	96 – 114	96 – 114	1,000	12,000 – 15,000	600 – 1,400	36	DBT America DDR 1,920
Arch-Mtn. Coal Company (West Elk)	B	276	144	950	3,500 – 9,000	1,400 – 2,200	40	Joy 6LS-2 DDR 1,720

9,540-foot-long panel, a 1,260-hp shearer, and shields with an 886-ton yield rating (*Coal Age*). The cutting height, face width, and shearer horsepower averages remained about the same as last year: 86 inches vs. 85 inches, 924 feet vs. 917 feet, and 1,260 hp vs. 1,235 hp respectively. The average panel length, however, made a 468-foot gain from 9,072 to 9,540 feet.

Colorado longwalls are still much larger than the average longwall face (Figure 31). According to *Coal Age* (Feb. 2003), since the high point of 1991 when 96 faces operated in the United States, the 52 remaining longwall faces still operating today have increased in strength, productivity, and capacity. These longwalls produce on average 4 million short tons per year each, or more than 20 percent of the nation's coal. These longwalls are much more productive than the 96 faces in 1991.

Deutsche Bergbau Technik (DBT), the German mining equipment manufacturing company, presented its 15,000th shield to Oxbow Mining at a special ceremony during January 2003 in Hotchkiss, Colorado. Executives and the miners and their families from Oxbow and DBT gathered to celebrate the company's achievement (*Coal Age*, Feb. 2003). In other longwall manufacturing news, DBT purchased the Long-Airdox Company from the Marmon Group in 2002.

Coal Quality and Reserves

The average quality of coal received at electric utilities in Colorado is compliant with Clean Air Act standards. Colorado utilities burned an average 9,797 Btu heat value, 0.38 percent sulfur, and 6.75 percent ash (EIA, 2001). 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). Holcim (U.S.), Inc. 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.

Most of Colorado's coal reserves are bituminous. In fact, 75 percent of Colorado coal produced in 2002 was bituminous. 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 2001 ranges between 0.4 and 0.7 percent sulfur. The national trend is for power plants to increase their demand for low-sulfur

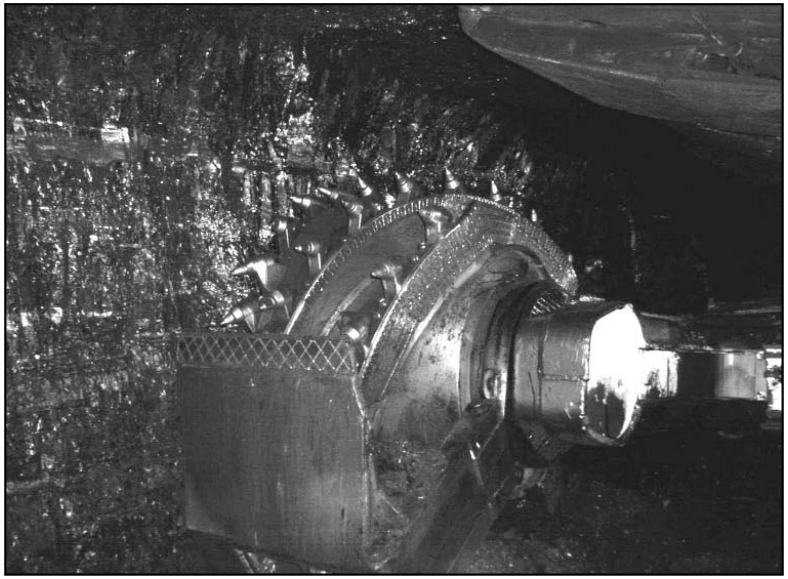


Figure 31. West Elk Mine longwall shearer, 2001. (Photo courtesy of Rocky Mountain Association of Geologists)

coal. EIA estimates that the United States will consume 400 million more short tons of low sulfur coal by 2020 from eastern Appalachia, Powder River, and the Rocky Mountain coal regions. This trend should keep Colorado as a productive coal mining state for many years to come.

About 75 percent of Colorado coal leases are federally owned. Nearly 50,000 acres are currently under lease. For 2001, the EIA reported that Colorado had 562 million short tons of recoverable coal reserves under lease. In terms of mining recovery, the average percentage of coal recovered at Colorado coal mines is 75.55 percent (2001 EIA data). For underground mines, the average recovery percentage for 353 million recoverable reserves was 68 percent; for the 209 million recoverable surface reserves, it was 89 percent (EIA, 2001).

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 (2001 data). Over 90 percent of Colorado coal reserves are less than 0.83 lbs. of sulfur per million Btu. The average quality of Colorado coal is 11,098 Btu/lb., 0.46 percent sulfur, and 8.31 percent ash (DOE/EIA 2001). In terms of compliance coal, 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 United States recently is the depletion of quality reserves. Thick seams of environmentally favorable coal quality in central Appalachia and the Illinois Basin are becoming more difficult to mine. If thin-seam, longwall mining becomes a reality through advancements in technology, then those markets become more feasible. Coal preparation helps marketability of poor quality coal. When all power plants in the United States install air pollution scrubbers on their towers, then high-sulfur coal can again be mined.

In 2002, President Bush proposed his Clear Skies Initiative for air pollution control. This proposal cuts power plant emissions of the three worst air pollutants, namely nitrogen oxides, sulfur dioxide, and mercury by up to 70 percent. The initiative is supposed to improve air quality using a proven, market-based approach. Colorado coal also has some of the lowest concentrations of trace elements such as aresenic and mercury in the nation. In particular, mercury associated with Colorado coal is considered very low. As a significant part of the President's Clear Skies Initiative, mercury is being looked at with great scrutiny. The Environmental Protection Agency was scheduled to issue a report on the impact of air pollutants last May, but the Bush Administration has delayed the report. Mercury emissions have not been regulated previously, and it is very difficult to trap at power plants. Congress must decide whether to use Clear Skies or the Clean Air Act, which has existing plans for mercury regulation (National Public Radio, Feb. 21, 2003). EIA expects that implementation of the Clear Skies Initiative would result in significant additions of emissions control equipment as the dominant compliance option for U.S. power plants.

Colorado Coal News

For 2002, the most significant coal industry developments were the higher than normal prices and stable marketplace enabling high production. No serious delays or problems occurred to disable production. In terms of economic productivity, the 12 coal mines in the state all produced at or near capacity, with many setting annual production records. The price of coal stabilized and Colorado's compliant coal product was much in demand.

Northwest Colorado Coal Mining News

Twentymile/Foidel Creek Mine (Figure 32) in Routt County produced 7.6 million short tons of coal in 2002, the largest supplier of Colorado coal. More than 95 percent of their coal is sold as mined (raw), with only crushing and size screening necessary for their 11,400 Btu, low sulfur coal. Twentymile is serviced by the Union Pacific Railroad, which runs two or

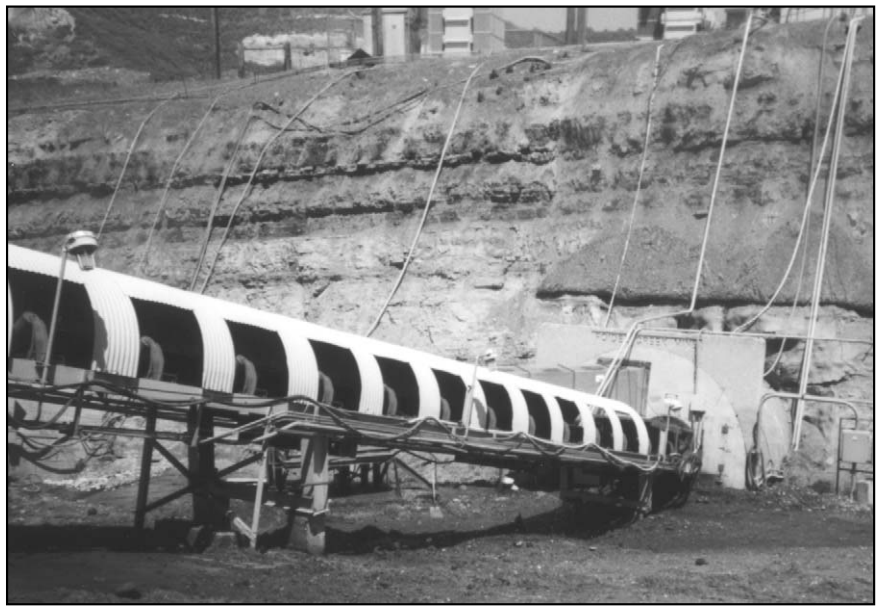


Figure 32. Coal is conveyed to the surface at Twentymile Mine.

Figure 33. Haul truck, Colowyo Mine.

three 10,000 ton-capacity unit trains per day from the mine. They supply in-state steam coal to Colorado Springs' Drake Power Plant, Xcel Energy's Cherokee and Valmont Plants in Denver and Boulder, and the Clark Plant in Canon City. Twentymile also exports coal to Mexican power plants, and shipped 544,000 tons in 2002. They also sell a small amount of stocker coal to the Rock Springs, Wyoming area (the only export to Wyoming). Twentymile sells coal to Seneca Coal Co. to supplement the Hayden Plant on a short-term basis. Twentymile mines the 8.5-9.5 feet-thick Wadge coal seam of the middle coal group of the Williams Fork Formation. Twentymile has enough coal to mine the Wadge seam under Twentymile Park for at least the next ten years.

The Seneca Strip Mines near Hayden (Yoast and Seneca II-W) also set their all-time annual production record. They produced 1.79 million short tons of coal in 2002. The two surface mines operated by Seneca Coal Co. and owned by Peabody Coal Co. also mine the Wadge coal seam of the Williams Fork Formation as well as the overlying Lennox seam. The mines are approaching overburden limitations on their high walls and must work with steeply dipping coal seams at times. Seneca may attempt to employ a high-wall miner in the 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.

Trapper Mining Company promoted Ray Dubois to general manager of the Trapper Mine in Craig. The mine is experimenting with a change from dip slope mining to a strike-line mining plan. This will allow for deeper seam recovery. 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 tons to the current reserve life. Recoverable reserves now are about 25 million tons, or twelve-year life.

Colowyo Coal Mine in Moffat County passed two significant mining milestones in 2002. Last summer marked their 25th year of continuous coal production, and the large surface mine produced its 100 millionth ton of coal (Figure 33). Colowyo becomes the first such mine to ever achieve this level in Colorado history. During the summer of 2002, Colowyo acquired six new Western Star tractor trailers for hauling coal to the loadout facility.

The "Section 16" pit was closed out in 2002 by mining the X-seam to the lease boundary. The east pit (Figure 34), which has been mined for 25 years, will also be completely mined out in 2003. By the end of the year the west pit will be the only operating surface pit. The mine also has a new general manager, Kelly Sanders, a Kennecott engineering manager with experience in Australia and Wyoming. His management group is conducting pre-feasibility studies to determine future surface and underground operations.

Figure 34. Colowyo Mine surface operations, Section 16 pit.

Colowyo has 145 million short tons remaining of recoverable surface reserves under lease, and an additional 111 million short tons of potentially underground mineable coal evaluated. Surface mining to the south and west is the immediate future beyond the west pit toward South Taylor and Wilson Creek areas. Approximately 52 percent of their coal is used as steam coal in-state. Colowyo ships 48 percent of their production out of state as steam and industrial use coal.

At the Colorado Mining Association's 105th National Western Mining Conference in February 2003, northwest Colorado mines won several awards. Tops among the Colorado Division of Minerals and Geology and the Colorado Mining Association reclamation winners was Colowyo Coal for the large surface mine award. Colowyo won for its use of state-of-the-art technology in mining and reclamation. In particular, their computer-aided earthmoving and Global Positioning System technology in surface mining equipment was considered very efficient. Blue Mountain Energy won the underground mining award for their reclamation of the Staley Gordon/East Portal area of the Deserado Mine. Colorado Yampa Coal Company won the 'Final Reclamation Award' for their reclamation of the Eckman Park No. 1 and No. 2 Mines. According to Stuart Sanderson, President of the CMA, "The final Phase III bond release involved approximately 2,400 acres of previously mined land. The site is the largest Colorado mine to complete the cycle of permitting, mining, reclamation and bond release." West Elk Mine also won a special award called the "Steep-Slope Reclamation Award" for its outstanding efforts in reclaiming the Lone Pine Fan Facility. The "Excellence in Reclamation Award" went to Snowcap Coal Company and J.E. Stover & Associates for their work to reclaim the Roadside North & South Portals Mine.

A very significant national reclamation award was presented to Trapper Mine in 2002. The U.S. Office of Surface Mining honored three mines with a special award as "the best reclaimed mines in the nation since the inception of SMCRA 25 years ago." Trapper Mine won the Bronze Medal at the special 25th Anniversary Awards for Excellence in Surface Coal Mine Reclamation since 1977. Trapper's award was presented for reclamation and sedimentation control projects which re-created a habitat for deer and elk on the mine's 10,000-acre permit area.

Somerset Coal Field News

Oxbow Mining closed the Sanborn Creek underground longwall mine in February 2003. The company will relocate its operations by opening the Elk Creek Mine in April 2003. The new mine will allow Oxbow to mine larger longwall panels. A new shield recently delivered by DBT will have a face extension from 580 feet to 800 feet (*Coal Age*, Feb. 2003). Sanborn Creek operated in the B seam, and two of the last three panels had more than 2,500 feet of overburden. This depth was very hazardous to mining (methane gas, pressure problems), and Oxbow is looking forward to mining in shallower depths (about 700 feet overburden). They will also be mining in a new seam, the D seam, which is 200 feet above the B seam. Four of the first six years of operation will be mining at less than 1,400 feet of overburden.

Sanborn Creek mined 3.2 million short tons of coal in 2002, a new annual production record for the mine, and a new monthly record in March 2002 (400,000 short tons). In its eleven year life Sanborn Creek Mine produced over 17 million short tons of high-Btu (12,300 Btu average), low-sulfur (0.5 percent) bituminous coal.

Methane gas problems at West Elk Mine lessened in 2002. West Elk was able to mine in shallower conditions than in 2001, which greatly reduced the amount of methane gas in the mine. Methane drainage holes on the property help to minimize the impact. West Elk set a new annual production record by producing more than 6.5 million short tons. Recently, West Elk moved their longwall into a new area that has less overburden.

With its new coal delivery system, Bowie No. 2 Mine (Figure 35) maximized coal production from its mine in 2002. Bowie is operating in the D-seam and produced a record 5.4 million short tons of coal. In addition to setting their new annual coal production record, in April, they set their all-time monthly production record with 569,000 short tons of coal. They are operating in their new lease area—Iron Point. In addition to their steam coal sales, Bowie sells about 320,000 short tons of coal per year to Coors Brewery in Golden, Colorado. While the mine is operating quite well, their parent company, Horizon Natural Resources, is not. They filed a second Chapter 11 bankruptcy notice in November. Bowie No. 2 operations were not curtailed, but Horizon may have to sell off less profitable parts of the operation in the east.

Other Colorado Coal Mining News

Lodestar Energy, which operates the McClane Canyon Mine in Garfield County, is currently for sale. They will cease operations soon and sell all company assets to pay off bankruptcy debt. McClane Canyon Mine reports that they still have a 2-year contract with the Cameo Power Plant and production should not be affected. The mine set an annual production record last year by producing 327,199 short

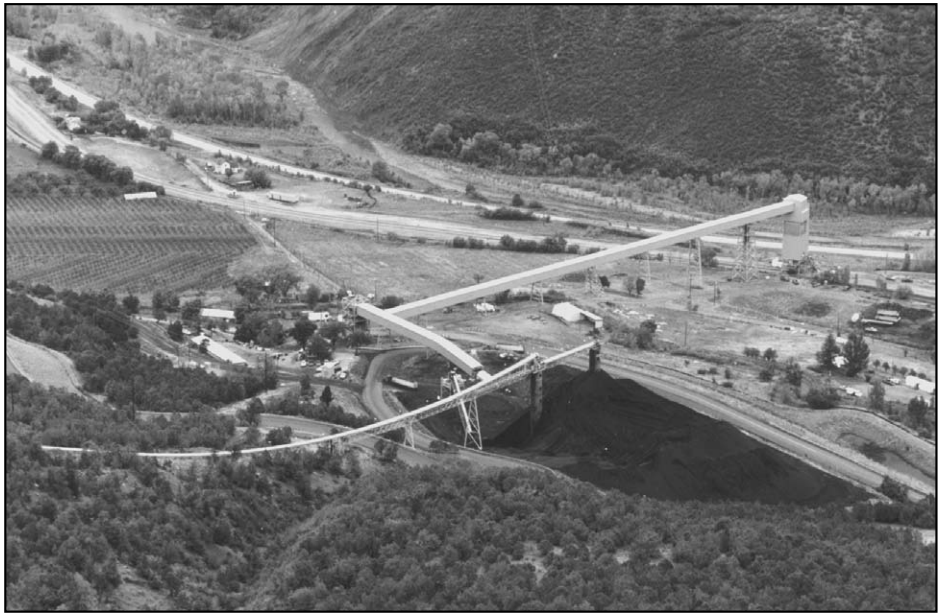


Figure 35. New surface loadout and conveyer system, Bowie No. 2 Mine.

tons of coal. They expect production to fall off slightly with retrofitting to the power plant operations, but no geologic or technologic restraints to mining are reported.

National King Coal's mine near Durango set new coal production records as well. King Coal reported 328,730 short tons produced in 2002, a new record for the 67-year old mine. In July 2002 they produced 38,906 short tons, an all-time monthly record. As of March 12, 2003, King Coal has new ownership. Alpha Natural Resources was created with a three-way merger between Coastal, Pittston, and AMCI. The company sells coal to cement manufacturing plants in New Mexico, Arizona, and Mexico. In 2002, King Coal sold about 150,000 short tons to cement plants in Mexico. King Coal trucks the coal from the mine to Gallup, New Mexico for rail transport to Mexico. King Coal also sells its 12,500 Btu coal to local blacksmiths, the Durango & Silverton Narrow Gauge Train, and individual household users. King Coal is Colorado's oldest and longest continually operating coal mine.

Deserado Mine in Rio Blanco County produced 2,008,876 short tons of bituminous Mesaverde Formation coal. The mine is owned and operated by Deseret Generation and Transmission Corp. of Utah to supply the Bonanza Power plant 34 miles west of the mine. Coal is washed and then conveyed to a train loadout. The private train line is unique in that it is the only privately run electrically powered train in the United States.

Southern Colorado's Lorencito Coal Co. has suspended mining operations indefinitely after losing a major coal contract (*Denver Post*, Aug. 2002). The shutdown leaves 40 employees without jobs. The 18,000-acre mine, 16 miles west of Trinidad, opened in September 2001 and had produced up to 1,000 short tons of coal per day at its peak in March 2002. Mine Manager Erik Addington said he made the decision to shut down in late-June after the mine lost a major coal buyer—the Tennessee Valley Authority. According to the Colorado Division of Minerals and Geology, the mine is anticipating re-opening this summer (2003) with a new client.

There is one new development on the coal exploration front. Radar Acquisitions Corp. of Alberta, Canada, has acquired 25,000 acres leased near Limon, Colorado to develop a coal and heavy mineral deposit in the Fox Hills Sandstone and Laramie Formation. Called the Limon Coal and Heavy Mineral Project, the company plans to mine both formations for coal, titanium, garnet, and zircon. The company is conducting a pre-feasibility study on the potential for a coal-fired power plant in the area. Radar says that the project could support a 750 to 1,000 megawatt power plant. Coal from three lignite seams in the basal Laramie Formation average 6,300 Btu heat value. The 3-feet thick A upper seam averages 0.36 percent sulfur, the 7-feet thick A seam has 0.31 percent sulfur, and the 4-feet thick B seam has 1.3 percent sulfur. It would be a mine-mouth surface operation. The company feels that the project would be successful because of the abundance of lignite in shallow dipping beds, and the close proximity to a large electrical market and transportation corridors (Interstate-70 and the railroad are nearby).

The coal industry in Colorado was healthy and economically viable in 2002. All economic variables are good, the price of coal is stable, and coal production and employment are up. In contrast to last year, however, coal sales have slowed in early 2003. Coal production is forecasted to decrease through 2003.

By John W. Keller

INTRODUCTION

Non-fuel mineral production in Colorado includes metals, industrial minerals, and construction materials such as sand and gravel. In 2002, a preliminary estimate by the U.S. Geological Survey of the total value of non-fuel mineral production in Colorado is $629 million. This is a 16.5 percent increase over the 2001 production value of $540 million. The increase in value is mainly due to increased production of gold, molybdenum, aggregate, and soda ash. Price increases for gold and molybdenum also added to the higher production value. Much of the mineral production data herein was obtained from the Minerals Information group of the U.S. Geological Survey, which can be accessed at http://minerals.usgs.gov/minerals/. Figure 36 shows the value of non-fuel mineral production in Colorado, and the percent of the total value of each commodity type. Figure 37 is a map of the major industrial mineral and metal mines in the state, and some of the exploration and development projects. Table 12 lists the mines and prospects, their owners, mine type, and commodity.

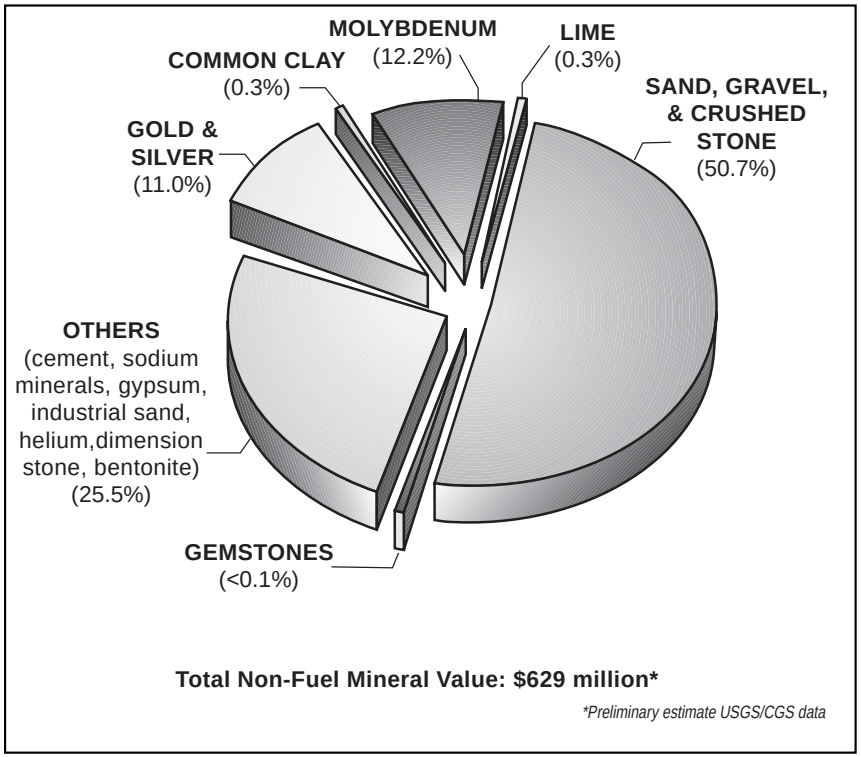


Figure 36. Colorado non-fuel mineral production value, 2002.

Table 12. Selected non-fuel mineral producers and prospects in Colorado. Numbers refer to map in Figure 37. (Excludes sand, gravel, and crushed stone operations).

MAP NO.	MINE/PROJECT	COMMODITY	MINE TYPE	OPERATOR
1	Kelsey Lake	diamonds	OP	Great Western Diamond Co.
2	Cripple Creek & Victor Mine	gold, silver	OP	Cripple Creek & Victor Gold Mining Co.
3	American Gypsum	gypsum	OP	Centex Construction Products, Inc.
4	Henderson	molybdenum	UG	Phelps Dodge Corp.
5	Sweet Home	rhodochrosite (specimen)	UG	Sweet Home Rhodo, Inc.
6	Yule Quarry	marble	UG	Sierra Minerals Corp.
7	White River	sodium bicarbonate	SOL	Natural Soda, Inc.
8	American Soda	soda ash and sodium bicarbonate	SOL	American Soda, LLC
9	Colorado Silica Sand	silica sand	OP	Oglebay Norton Industrial Sands
10	Ladder Creek Plant	helium	P	Duke Energy Field Services
11	Pride of the West Mill	gold, silver, base metals	P	Silver Wing Co., Inc.
12	Portland	limestone / cement	OP/P	Holcim, Inc.
13	Caribou	gold	EX	Calais Resources

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

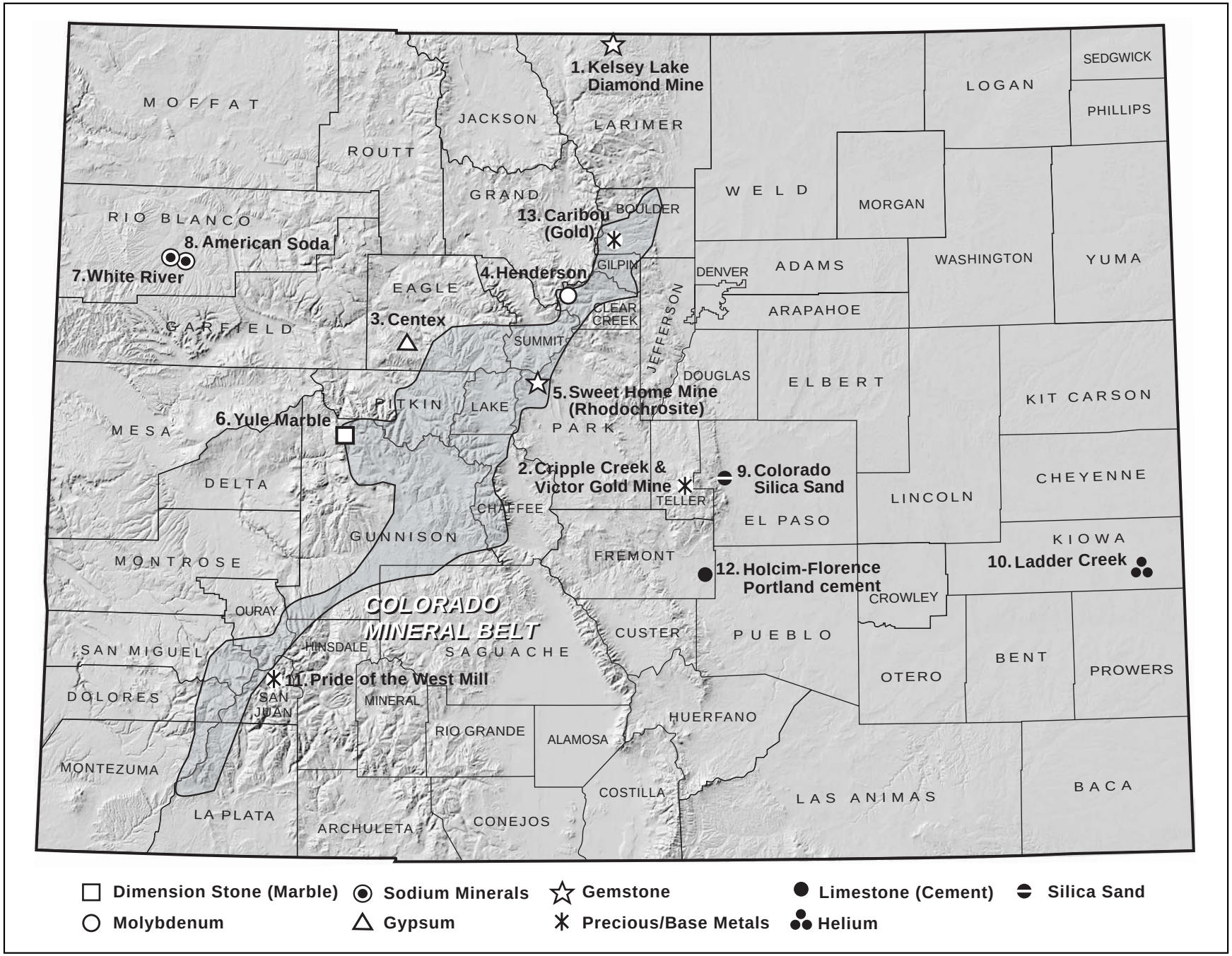


Figure 37. Map of major metal and industrial minerals mines and prospects (does not include sand, gravel, or crushed stone operations).

Figure 38. One of several 310-ton capacity trucks purchased by the Cripple Creek & Victor Mine for its $168 million expansion.

mine will be ramping up gold production in 2003 to an estimated 340,000 ounces (Figure 39). When the full benefits and efficiencies of the expansion are realized, the mine is expected to produce 400,000 ounces of gold per year. The current reserve base is sufficient to support gold production until 2012. 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.

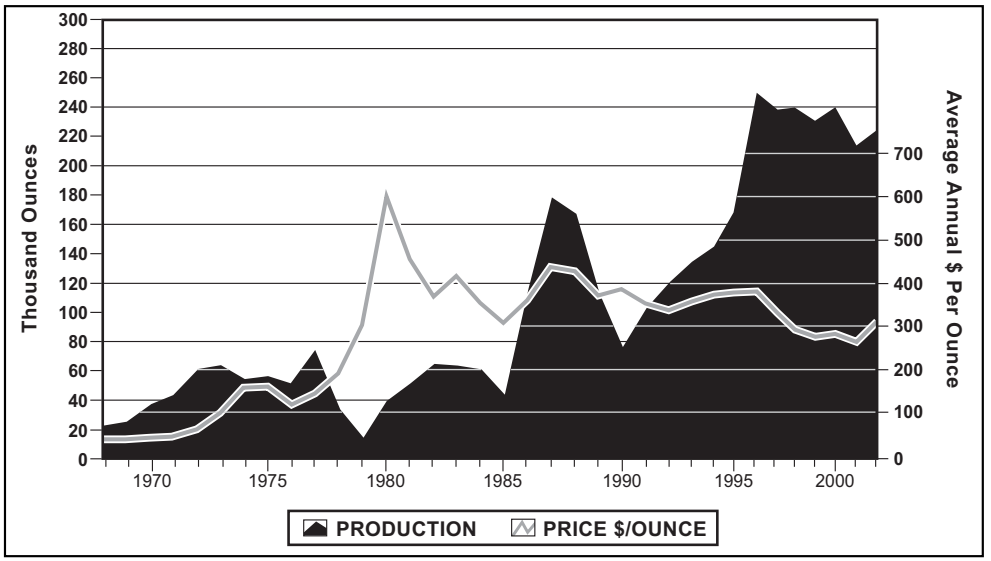


Figure 39. Colorado gold production, 1968—2002.

METAL MINING

Gold and Silver

Cripple Creek & Victor Mine, Teller County

The Cripple Creek & Victor Gold Mining Co. (CC&V) continues to operate the only major precious metals mine in Colorado. The Cripple Creek & Victor Mine in Teller County produced 224,000 ounces of gold in 2002, up 4.6 percent from the 214,000 ounces produced in 2001. The increase is due to the October completion of the $168.5-million expansion and capital improvement project. The project included a new fleet of 310-ton haul trucks (Figure 38), an expanded heap leach pad, construction of a new maintenance facility, a new crushing facility, and an expanded gold recovery plant. Gold prices increased substantially in 2002, averaging about $310 per ounce. This is a 14 percent increase from the 2001 average of $273 per ounce. The value of the gold produced at the mine in 2002 is estimated to be $69 million. The

Gold was originally discovered in the Cripple Creek district in 1891. Since then, the district has produced about 23 million ounces of gold, easily making it the largest gold-producing area in Colorado 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 (Figure 40) northeast of Silverton in San Juan County has been rehabilitated to process ore from mine waste piles in the Animas River watershed. The project is managed by the Silver Wing Co., Inc. Silver Wing also owns a 90 percent interest in the Gold King Mine, which may eventually provide fresh ore to the

Figure 40. Pride of the West Mill near Silverton, San Juan County. (Photo courtesy of Steve Fearn)

mill. In February 2003, the project received final approval from one state to begin processing the ore. The mill is expected to start production in the spring of 2003. 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. The concentrates will be shipped to smelters out of state. A small carbon-in-pulp cyanide leach system will scavenge gold from ore in enclosed agitation tanks at the end of the milling process. The cyanide in solution is then destroyed by hydrogen peroxide. The company is currently in the process of constructing a liner for the tailings pond. A 15,000-ton stockpile of ore from mine tailing waste piles is already at the site awaiting processing, delivered by the Animas River Stakeholders Group. Gold King Mines Corp. (a subsidiary of Silver Wing Co., Inc.) has acquired the American Tunnel Water Treatment Plant at Gladstone. The water treatment plant is necessary to process mine water when the Gold King Mine begins operation. Rehabilitation of the underground workings at the Gold King Mine is expected to commence sometime in 2003.

The Pride of the West milling project has strong support and assistance from the Animas River Stakeholders Group—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. Some of the group's funding is derived from U.S. Environmental Protection Agency grants. The project has received financial assistance (loans) from Region 9 Economic Development District and San Juan 2000 Economic Development Association which is a local San Juan County group. Local business and economic development groups appreciate the project because it will diversify the area's economy, employing as many as 50 people when it achieves full production.

Caribou Consolidated District (Exploration and Development), Boulder County

Calais Resources announced that an extensive exploration and resource expansion drilling program is slated to begin in June 2003 at this project in Boulder County. The current proven and probable resource is 450,000 ounces of gold and 20 million ounces of silver. Calais Resources hopes to expand the total resource to over one million ounces of gold and 30 to 40 million ounces of silver. Several previously unexplored geological targets will be drilled as well.

Grace Mine (Development), Clear Creek County

The Grace Mine, an historic gold mining property located near Empire in Clear Creek County, is under consideration for development into a working mine. According to an article in the October 31, 2002 Denver Post, a partnership that includes Transcontinental Minerals Inc., Consolidated Empire Mines Ltd., and MR3 Systems Inc. propose to conduct surface mining initially, with possible underground mining in the future. The ore would be partially processed at a mill on-site, and further processed at a proposed facility in Denver. The mine as proposed would employ 25 to 35 workers. The Grace Mine produced nearly 200,000 ounces of gold from the 1860s to the 1930s.

La Plata District (Exploration), La Plata County

In December 2002, Gold-Ore Resources Ltd. completed the purchase of La Plata Minerals Ltd. which wholly owned a copper-precious metals porphyry deposit in the La Plata Mountains northwest of Durango. The La Plata property includes the Allard zone and the Copper Hill zone, areas with significant historical mine workings. Gold-Ore has completed surface geochemical sampling in the area. In 2003, the company plans to compile existing geological and assay data from previous operators to evaluate the precious metal potential of the project area.

Newmont Mining Corp., Denver

Newmont Mining Corp. of Denver became the largest gold mining company in the world when it completed its buyout of Normandy Mining, Ltd. of Australia and Franco-Nevada Mining Corp. Ltd. of Canada in early 2002. At the end of 2002, Newmont reported equity gold reserves of 86.9 million ounces worldwide. Although Newmont does not have any operating mines in Colorado, the company is a major employer of mineral exploration and mining industry professionals in the Denver area. In addition to its corporate headquarters, Newmont operates the gold industry's largest research and development laboratory at a facility in the Denver area.

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. In 2002, the mine and mill produced 20.5 million pounds of molybdenum metal contained in concentrates, an increase of 9 percent from the 18.8 million pounds produced in 2001 (Figure 41). The increased production was due to a slight increase in ore grade through the mill. According to the U.S. Geological Survey Mineral Information Office, the 2002 average price for molybdenum contained in technical-grade molybdic oxide was $3.75 per pound—up significantly from an average of $2.36 in 2001. The price reached as $9 per pound in early June 2002 because of fears of a supply shortage. The value of molybdenum produced

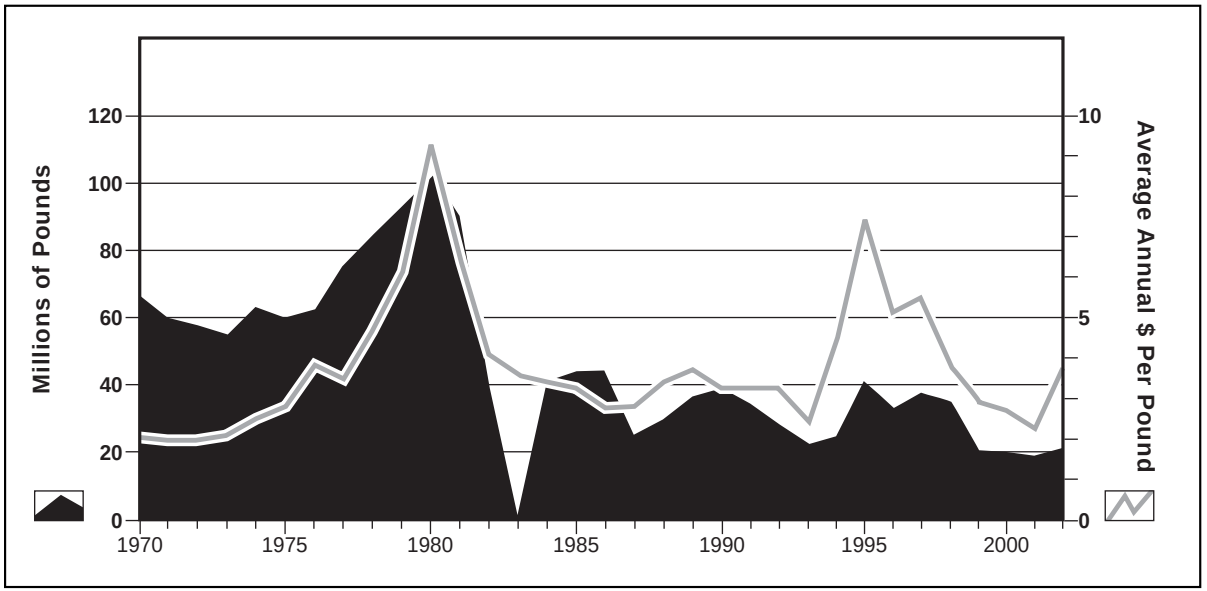


Figure 41. Molybdenum production in Colorado, 1970—2002.

at Henderson in 2002 is estimated to be $77 million. The operation continues to employ about 320 workers at the mine and mill.

The Henderson orebody is elliptical in shape and lies about 3,500 feet beneath the summit of Red Mountain. It occurs within a Tertiary-age rhyolite porphyry intrusive complex that was localized by the Berthoud and Vasquez faults. 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.

Uranium and Vanadium

There was no uranium production in Colorado in 2002, but mine development activity has been taking place on the Western Slope. Uranium prices increased again in 2002. The average price for uranium oxide was $9.90 per pound compared with $8.80 per pound in 2001. The steady price increase has encouraged some exploration and mine development activity. Cotter Corporation has begun development of a small uranium-vanadium mine in Montrose County. The JD-9 deposit, a U.S. Department of Energy lease tract, is a sandstone-hosted deposit containing about 0.5 percent U_3O_8 and 2.1 percent vanadium. The mine is expected to produce 5,000 tons of ore per year. The ore will be processed at Cotter's mill in Canon City.

Cotter's Schwartzwalder Mine in Jefferson County ceased production of uranium ore in early 2000. The mine produced a total of 1.2 million pounds of uranium oxide (U_3O_8) between 1995 and 2000. Currently, the uranium mine site is undergoing reclamation. The underground mine is being allowed to flood and the water level is up to the 800-foot level. The company is actively pursuing opening a new underground aggregate quarry on the property.

INDUSTRIAL MINERALS AND CONSTRUCTION MATERIALS

The largest segment of the non-fuel mineral industry in Colorado is 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 and Gravel and Crushed Stone (Construction Aggregate)

The top uses for aggregate are road base and coverings, concrete and asphalt, and fill material. Colorado produced nearly 62.5 million tons of aggregate in 2002 (Figure 42) and ranked 8th in the nation for sand and gravel production. In 2002, 61 percent of Colorado's aggregate production was sand and gravel, while 39 percent was crushed stone. Sand and gravel production is up 9.2 percent from 41.1 million tons in 2001 to 44.9 million tons in 2002. Similarly, crushed stone has increased 15.2 percent over last year's total. The total value of Colorado aggregate production in 2002 was $319 million. This is an increase of 13 percent over the 2001 value of $282 million. The average unit value of Colorado sand and gravel was $4.79 per ton. Colorado crushed stone had an average value of $5.90 per ton. Figure 43 shows the price trend for these commodities since 1992. LaFarge Corp. is Colorado's leading producer of sand, gravel, and crushed stone.

Prior to 1975, the national trend in aggregate production was towards sand and gravel. Since the mid-1980s however, crushed stone production has surpassed sand and gravel production, and the gap between the two continues to increase (Figure 44).

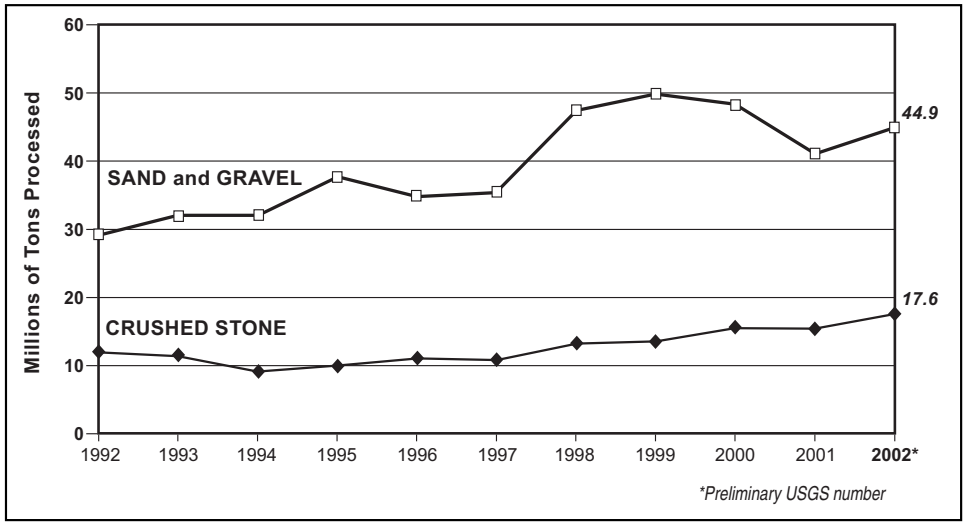


Figure 42. Production of sand and gravel vs. crushed stone in Colorado, 1992—2002.

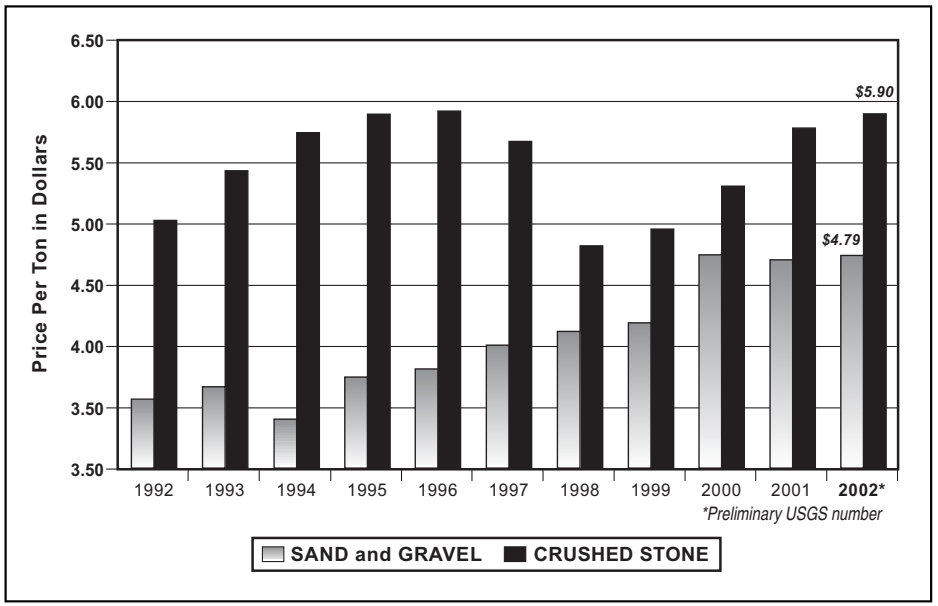


Figure 43. Average estimated price per ton of sand and gravel versus crushed stone in Colorado, 1992—2002.

Soda Ash and Sodium Bicarbonate

Soda ash (Na_2CO_3) is used primarily in the manufacture of glass, soap and detergents, and other chemicals. Another major use is 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. Nahcolite is a naturally occurring sodium bicarbonate mineral that is present in large quantities in the sedimentary rocks of the Piceance Creek Basin in northwestern Colorado. It is estimated that 32 billion tons of nahcolite are present within the basin.

American Soda LLP, Rio Blanco County

In late 2000, American Soda, LLP began production of soda ash and sodium bicarbonate in Rio Blanco County. The company built a state-of-the-art solution mine with 26 production

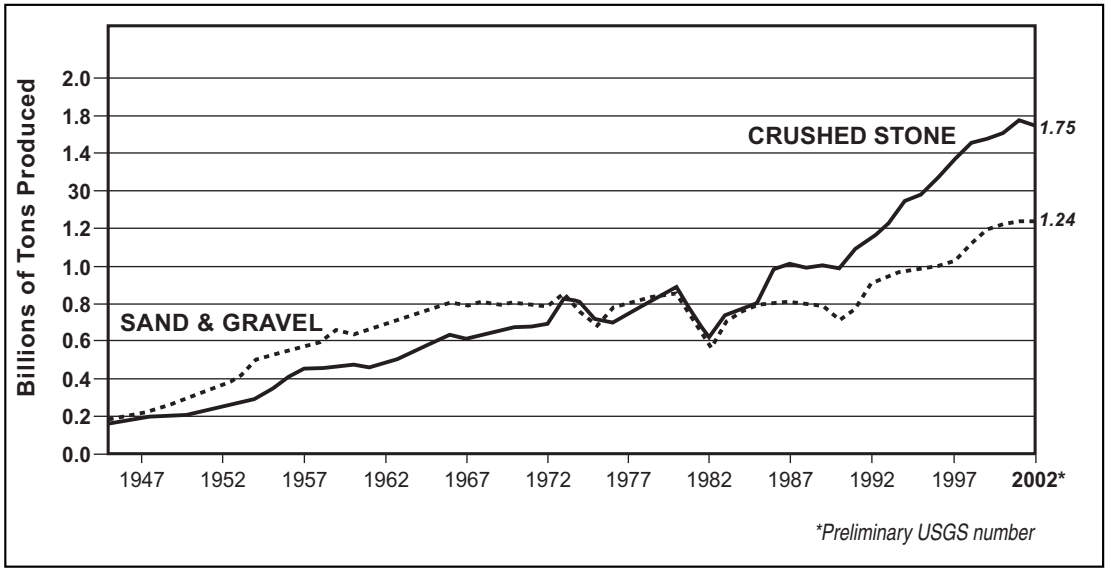


Figure 44. U.S. production of sand and gravel vs. crushed stone, 1945—2002.

wells, a 44-mile dual pipeline, a processing plant near Parachute in Garfield County, and a rail spur to produce and ship its sodium products (Figure 45). The mine and plant have a nameplate production capacity of 800,000 tons per year of soda ash and 150,000 tons per year of sodium bicarbonate. In 2002, the second full production year, the company shipped 550,000 tons of soda ash and 70,000 tons of sodium bicarbonate. The soda ash production is a 76 percent increase from the 313,000 tons produced in 2001. In 2003, the company is expecting to increase production to near nameplate capacity. Ten to twelve new production wells are to be completed in 2003. The average life of each well is three to three and a half years.

The solution mine, located in Rio Blanco County within the Piceance Creek Basin, consists of production wells that use hot water to dissolve nahcolite (natural sodium bicarbonate) from several stratigraphic horizons in the Eocene-age Green River Formation, which lies about 2,000 feet below the surface. The company controls over 7,000 acres of mineral leases on BLM land. They estimate that the nahcolite in situ resource is 3.5 billion tons, with over 1 billion tons of recoverable nahcolite.

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. Natural Soda AALA intends to refurbish and expand the mine and plant as soon as possible to ensure a production rate of more than 100,000 tons per year. 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 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.

Figure 45. American Soda's nahcolite mine plant and pipelines in Rio Blanco County.

Gypsum

American Gypsum, Eagle County

Centex Construction Products Inc.'s American Gypsum operation produced 550,000 tons of gypsum in 2002 from its mine in Eagle County. That figure is a slight increase from the 2001 production of 543,000 tons. In 2002, the company received a special-use permit from Eagle County for the relocation of its mining operations as reserves at the current mine site are depleted. Over a span of a few years, mining will shift to the new site. The future mining area ensures that the wallboard plant in the town of Gypsum can operate for at least another 20 years. The new mine site will be northeast of the current operations. 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 United States. The mine and plant employ approximately 120 people. The bedded gypsum deposit is within the Eagle Valley Formation evaporite sequence of Pennsylvanian age.

Smaller gypsum mines in Fremont and Larimer Counties produce gypsum for mainly agricultural uses. Gypsum in northern Larimer County is mined from beds within the lower part of the Lykins Formation of Permian age. Near Canon City in Fremont County, gypsum is mined from beds within the Ralston Creek Formation of Jurassic age.

Cement

Holcim (United States) Inc., Fremont and Larimer Counties

Holcim (U.S.) Inc. operates one portland cement manufacturing plant in the state the Portland Plant near Florence. In August 2002, Holcim shut down, the La Porte Plant near Fort Collins. The Portland Plant completed a $225 million expansion in 2001 that nearly doubled its capacity from 1.0 million to 1.9 million tons per year. The plant converted from the wet process to the dry process. It employs about 180

people. Limestone from the Fort Hays Member of the Niobrara Formation of Upper Cretaceous age is mined as the principle raw ingredient for the cement.

GCC Rio Grande, Inc., Pueblo County

The GCC Rio Grande, Inc. (formerly Rio Grande Portland Cement Company) is a subsidiary of Grupo Cementos de Chihuahua, a Mexican cement company. It has been planning and permitting a new cement plant in Pueblo during the past several years. The company plans to spend approximately $200 million to build the mine and processing plant and produce about 2.5 million tons of cement per year, with around 100 employees. The company has signed a lease with the Colorado State Land Board to mine limestone from a local deposit for cement manufacture. 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 is scheduled to begin in mid-2003.

Clay and Shale

Common clay is used mainly for brick making, and shale is mined to produce lightweight aggregate. Clay is mined primarily in eastern Colorado—especially near the Front Range in Jefferson, Elbert, Douglas, El Paso, Pueblo, and Fremont Counties. In 2002, mines in Colorado produced a total of 325,000 tons of common clay valued at about $1.66 million. Clay is mined principally from three formations in eastern Colorado: the Laramie Formation (Upper Cretaceous), the Dakota Sandstone (Lower Cretaceous), and the Dawson Arkose (Tertiary).

Shale is mined from the Pierre Shale of Cretaceous age in northern Jefferson County by TXI for use as lightweight aggregate. The shale is then 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 multistory buildings. Cinder blocks are commonly made with lightweight aggregate.

Figure 46. Inside the Yule Quarry in Gunnison County.

Dimension Stone

In 2002, 11,200 tons of dimension stone with an estimated value of just over $2 million was quarried in Colorado.

Yule Quarry, Gunnison County

The Yule Quarry (Figure 46) in Gunnison County will continue to produce fine-quality marble in 2003, but at a somewhat diminished rate. In 2002, the Yule Quarry produced 45,000 cubic feet (3,825 tons) of marble. That was a decrease of about 22 percent compared to the 4,937 tons quarried in 2001. In 2003, the quarry will produce a large block that will be used to replace the Tomb of the Unknowns in Washington, D.C. The fresh block of marble for the Tomb is scheduled to be hauled out of the quarry and down the mountain on July 4th, with a celebration and ceremony to mark the occasion. The marble from the quarry is also used by monument fabricators and sculptors. The owner of the quarry is Sierra Minerals Corp. of Centennial, Colorado. The quarry employs 13 people. The stone is marketed under the name Colorado Yule Marble.

The Yule Quarry has a long and colorful history. It opened in 1886 shortly after mining claims were patented. The first major project where marble from the quarry was used was the construction of the Colorado State Capitol building in 1895. The Lincoln Memorial and the Tomb of the Unknowns in Washington, D.C. were constructed with Yule Marble. At one time, the marble fabrication plant in the town of Marble near the quarry was the largest of its kind in the world. The quarry was idle between 1941 and 1990. In 1990, the Colorado Yule Marble Company reopened the quarry as demand for natural stone tile and slab increased in the United States. The company had financial difficulties, however, and the quarry was closed again in March 1999. Sierra Minerals Corp. acquired a lease on the property and began production of marble in August 1999.

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 Dakota Sandstone is also quarried in several places around the state.

Alabaster has been quarried since 1969 at a site in the foothills near Fort Collins by

Colorado Alabaster Supply. Alabaster is used mainly for artistic media by sculptors. The White Banks Mine in Pitkin County produces alabaster, dark-colored marble, and quartz.

Industrial Sand

Ohio-based Oglebay Norton Company mines and 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. The sand is also used for landscaping purposes. The company quarries the sand near Colorado Springs from Quaternary-age eolian deposits that are composed of mostly well-sorted and well-rounded grains of quartz. In 2002, about 71,000 tons of industrial sand and gravel were produced in the state. No estimate of the total monetary value of this production has been made public.

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 presently 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 2002 was $267,000. This is a slight decrease compared to 2001, when $269,000 worth of gemstones were produced.

Diamonds

Great Western Diamond Company, Larimer County

The Kelsey Lake Mine, in Larimer County near the Wyoming border, produced diamonds through April 2002. As of early 2003, the mine was in care-and-maintenance mode. The company is currently seeking additional financing in order to resume production. In 1996, a 28.3-carat light-yellow diamond was recovered at the mine—the fifth largest diamond ever found in the United States. 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. The reserve is estimated at 18.7 million tons grading 3.4 to 4.6 carats per 100 tons of kimberlite ore.

The Kelsey Lake diamond resource consists of two kimberlite pipes in the State Line district—the Kelsey Lake-1 and Kelsey Lake-2. 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. Howard Coopersmith, a geologist who has been involved with finding the diamonds in the area since 1975 and who is now vice president of operations for Great Western, believes that diamonds weighing up to 100 carats will likely be discovered as mining proceeds. The prediction is based on a geostatistical analysis of the deposit. The mine and recovery plant employ about 25 people when in production.

Consolidated Pacific Bay Minerals Ltd.

In March 2002, Consolidated Pacific Bay Minerals Ltd. of Vancouver, B.C. announced it had completed a "potential diamond production study" on the George Creek property in the State Line district in northern Larimer County. No details of the study were announced, although a company press release suggests that there is potential for a viable diamond mining operation at the site. The average grade of the 5-ft-wide, mile-long kimberlite dike at the Greens Creek property is quoted in the same press release as being 75 carats per 100 tons.

Rhodochrosite

In April 2002, Governor Owens signed a bill making rhodochrosite (manganese carbonate, $MnCO_3$) the official State Mineral of Colorado. 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.

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 is Colorado's official State Gemstone. It is a form of beryl—a silicate mineral. Gem-quality light blue crystals are found in Colorado around the 13,000-foot elevation of 14,000-foot Mount Antero in the Sawatch Range in Chaffee County. The aquamarine crystals are found in large miarolitic cavities within pegmatites in 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. Many mineral collectors visit the site every summer.

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. Other turquoise mines 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. These mines are not currently active.

Helium

Grade-A helium is produced at the Ladder Creek gas processing plant near Cheyenne Wells in southeastern Colorado. The helium is produced by separating it from the other natural gases. It is liquefied at –458°F. Helium is used for several purposes including cryogenic applications (24 percent), pressurizing and purging (20 percent), welding cover gas (18 percent), and controlled atmospheres (16 percent). The total U.S. private production of Grade-A helium in 2002 was estimated by the U.S. Geological Survey to be 3.1 billion cubic feet, with an estimated value of $250 million. The Colorado portion of this production has not been publicized. Only five other states—Kansas, Texas, Oklahoma, Utah, and Wyoming — produce helium.