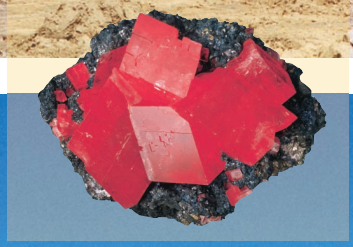
Information Series 63

Colorado Mineral and Mineral Fuel Activity

2001



By
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James A. Cappa
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and Thomas J. Hyde

Colorado Geological Survey • Division of Minerals and Geology • Department of Natural Resources • Denver, Colorado • 2002

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COVER:
Seneca Coal Company, Yoast Mine dragline; Rhodochrosite specimen from the Sweet Home Mine, Park County (specimen courtesy of Dave Bunk, photo by Jeff Scovil); Natural gas well surface facilities, Piceance Basin

Graphics/layout by PJ Hasselbach

Colorado Geological Survey
Division of Minerals and Geology
Department of Natural Resources
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FOREWORD

The purpose of Colorado Geological Survey Information Series 63, *Colorado Mineral and Mineral Fuel Activity, 2001* is to describe exploration, development, and production activity of the gas and oil, coal, and mineral industries of the state in 2001. The report is required by Colorado Revised Statutes 34-1-103(6), which states "The state geological survey shall prepare an annual report describing the status of the mineral industry and describing current influences affecting the growth and viability of the mineral industry in the state, and setting forth recommendations to foster the industry." The report also includes information on the economic impact of these industries to the state. The staff of the Mineral and Mineral Fuels Section of the Colorado Geological Survey gathers this information through the report year and writes this report every March. The objective of this publication is to provide geological information to resource developers, government planners, and interested citizens.

Funding for this project came from the Colorado Department of Natural Resources Severance Tax Operational Fund. Severance taxes are derived from the production of gas, oil, coal, and minerals.

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Chief, Mineral and Mineral Fuels Section

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INTRODUCTION AND ECONOMIC FACTORS

The Colorado Geological Survey Mineral Resources Section estimates the total value of 2001 mineral and mineral fuel production in Colorado to be $4,278 million dollars, a 0.9 percent increase from the (revised*) 2000 total value of $4,251 million (Figure 1).

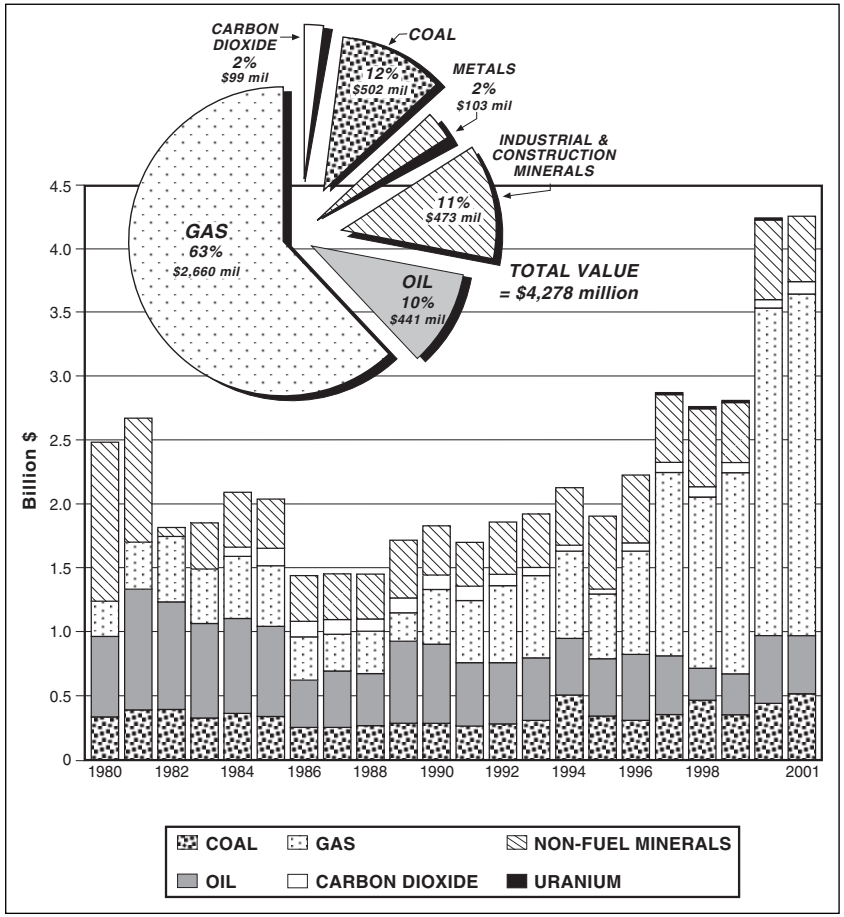


Figure 1. Value of Colorado mineral and mineral fuel production.

Mineral fuel and carbon dioxide production values for 2001 are estimated at:

- oil: $441 million
- natural gas: $2,660 million
- carbon dioxide: $99 million
- coal: $502 million

The total estimated value of oil, natural gas, and carbon dioxide production in 2001 was $3,200 million, which is just about flat compared the 2000 value of $3,216 million. Even though gas production increased and oil production remained steady, prices for gas and oil declined during the latter part of 2001.

Coal production increased from the 2000 level of 29.1 million tons to a record 33.4 million tons in 2001. Coal prices, which vary from mine to mine, are estimated at an average $15 per ton for 2001. The value of Colorado coal production is estimated at $502 million, up 15 percent from the 2000 value of $436 million.

The U.S. Geological Survey Mineral Information Office estimates the value of the 2001 non-fuel mineral production to be $576 million. This figure is a decrease of 3.3 percent from the 2000 value of $596 million.

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 2001 is $64.584 million, a 41 percent increase from the 2000 value of $45.780 million. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (Figure 2).

*This report was written in March, 2002. Oil and gas and non-fuel mineral production values are always estimates for the preceding year. Final production values are usually available by the end of the following year.

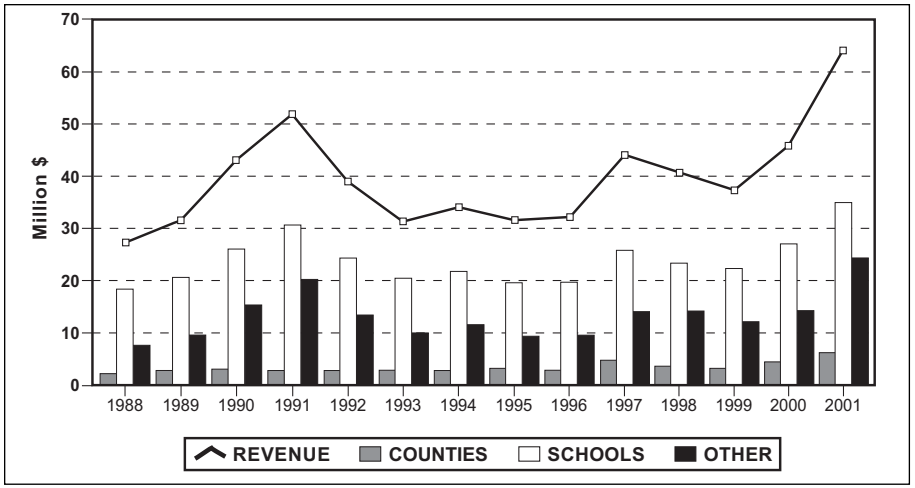


Figure 2. Federal mineral lease revenue and distribution in Colorado.

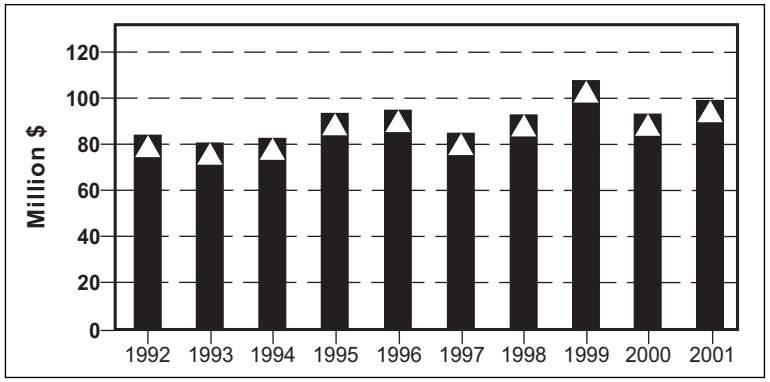


Figure 4. Property tax revenues from mineral properties.

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 the Colorado Department of Local Affairs, which distributes money through a variety of mechanisms to local governments. The other 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 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 2001 were $61.2 million, up 94 percent from the 2000 severance tax collection of $31.95 million (Figure 3). Estimated property taxes paid in 2001 to the counties from mineral and mineral fuel properties totaled $98.59 million (Figure 4). La Plata, Weld, and Clear Creek counties all received over $10 million each in mineral property tax revenue.

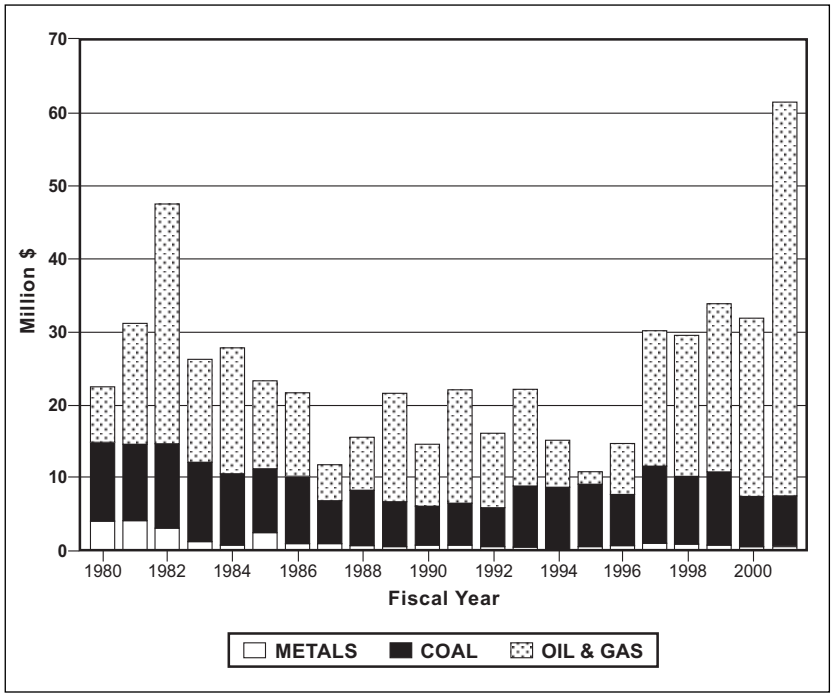


Figure 3. Colorado severance tax proceeds.

The University of Colorado College of Business Administration estimates employment in the mineral and mineral fuel industries in 2001 to be 13,500 workers, a 3.8 percent increase from the 2000 level of 13,000 workers. This small increase ended a steady ten-year decline in mining and oil and gas employment from a 1990 level of 21,300 persons.

GAS, OIL, COALBED METHANE, AND CARBON DIOXIDE

By Laura L. Wray and Thomas J. Hyde

Executive Summary of Statistics

2001 Statistics	Value*	Percent Change from 2000
Total Natural gas production (incl. coalbed methane)	785 BCF(e)	+1.8
Coalbed methane production	420 BCF(e)	+2.4
Conventional gas production	365 BCF(e)	+1.1
Oil production	19.0 MMBO(e)	-0.5
Carbon dioxide production	309.4 BCF(e)	-0.4
Value of gas production (conv'l and CBM)	$2.66 billion(e)	+3
Coalbed methane (CBM) production	$1.30 billion(e)	+4
Value of crude oil production	$441 million(e)	-18
Value of carbon dioxide production	$99 million(e)	0
Estimated Value of Production	**$3.20 billion(e)**	**-0.6**

2000 Statistics	Value*	Percent Change from 1999
Total Natural gas production (incl. coalbed methane)	771 BCF	+6.5
Coalbed methane production	410 BCF	+4.0
Conventional gas production	361 BCF	+9.3
Oil production	19.1 MMBO	0
Carbon dioxide production	310.7 BCF	+2.0
Value of gas production (conv'l and CBM)	$2.58 billion	+ 80.2
Coalbed methane (CBM) production	$1.25 billion	+56.3
Value of crude oil production	$537.4 million	+16.7
Value of carbon dioxide production	$99 million	+3.1
Total Value of Production	**$3.22 billion**	**+75.4**

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

Introduction and Review of the Year 2000

(In reading through this report, please refer to the glossary of selected terms and acronyms that has been included in Table 10, page 22.)

In 2000, the total value of natural gas (including CBM), crude oil, and CO_2 jumped to $3.2 billion (Figure 5). The contribution of high prices during the first half of 2001 offset the dramatic price plunge that culminated in: 1) the lowest gas prices in two years; 2) the greatest one-day drop in oil prices in a decade in late September; and 3) a worldwide reduction in the demand for petroleum products.

The year 2000 was a banner year for the gas and oil industry. Petroleum prices and particularly natural gas prices, soared to record levels. The year 2001 was the year of counter-balance; natural gas prices that peaked at almost $10 per thousand cubic feet (MCF) at the beginning of the year dipped below the $2 per MCF level by the end of the year. Similarly, the Organization of Petroleum Exporting Countries (OPEC) met frequently to discuss and implement, in some cases, reductions in production caps needed to offset falling crude oil prices.

The enthusiasm created by high gas prices and upward-spiraling demand for fuels to generate electricity was further bolstered by the growing awareness of the vast natural gas reservoirs stored in Rocky Mountain (and especially Colorado) reservoirs. The Potential Gas Committee estimates that 235 trillion cubic feet (TCF) of natural gas, representing 28 percent of the total U.S. gas reserves, exists within southern Rocky Mountain reservoirs. Of particular allure to the petroleum industry is that only 15 percent of those known reserves have been produced.

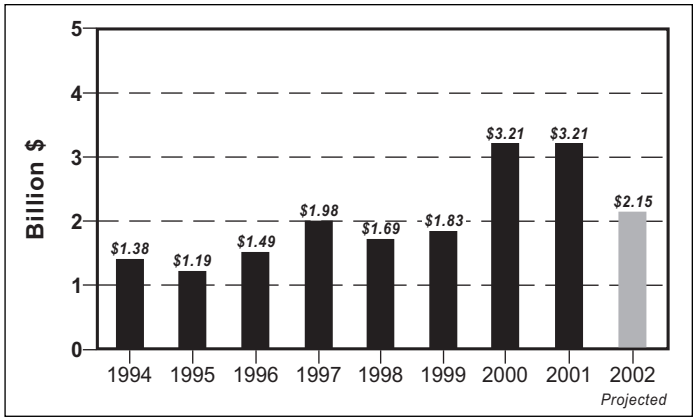


Figure 5. Colorado gas and oil production values 1994–2002.

Independent gas and oil companies produce approximately 75 percent of the domestic natural gas supply. The Denver area is home to approximately 300 independents. These are companies that, on average, employ 11 full-time and two part-time employees, generate median gross revenues of $4 million annually, and reinvest the majority of their cash flow into additional drilling. The large number of independents in the Denver area confirms the economic importance of these western U.S. reserves. (Independent Petroleum Association of Mountain States [IPAMS], 2002, "*Independents = Independence: IPAMS Washington Call-Up*," February 5–7, 2002, 13 p).

The following summary of Colorado petroleum statistics for the years 2000 and 2001 measures the ways in which the industry responded to the dramatic price fluctuations and a period of economic slow-down.

Colorado Production Statistics for Gas, Coalbed Methane, Crude Oil, and Carbon Dioxide

Final 2000 year-end numbers, compiled by the Colorado Oil and Gas Conservation Commission (COGCC), signified almost the end of the short-lived recovery in the petroleum industry. Price and demand records for natural gas set late in the year soon ricocheted downwards to more than six months of rock-bottom gas prices and diminished demand in the last half of 2001.

Natural Gas and Coalbed Methane

The historically high gas prices that spiraled upward in late 2000 and continued into the first quarter of 2001 contributed to another successive year in price and production increases for natural gas. Figure 6 illustrates this trend using national, 12-region composite spot wellhead prices (UBS Warburg LLC, *NatGas Insight*, February 14, 2002).

Commodity prices in Colorado, as in the U.S., benefited greatly from the dramatic rise in the natural gas and crude oil prices in late 2000. Figure 7 highlights the steady rise of natural gas production since 1983.

Production numbers and values for 2000 in Colorado are summarized below for natural gas and CBM (also see Figure 7):

- 771 BCF of natural gas and CBM produced (+6.5 percent from 724 BCF in 1999);
- 410 BCF of CBM produced (included in total above) (+4.0 percent from 394 BCF in 1999);
- $2.58 billion generated from natural gas and CBM production (+80.2 percent increase from final 1999 production numbers as reported by COGCC);
- $1.25 billion generated from CBM production alone (+56.3 percent from final 1999 production numbers as reported by COGCC).

Estimated production numbers and values for 2001 in Colorado are summarized below for natural gas and CBM:

- 785 BCF of natural gas and CBM produced (+1.8 percent from 2000);
- 420 BCF of CBM produced (included in total above) (+2.4 percent from 2000);
- $2.66 billion generated from natural gas and CBM production (+3 percent from 2000);
- $1.30 billion generated from CBM prod. alone (+4 percent from 2000).

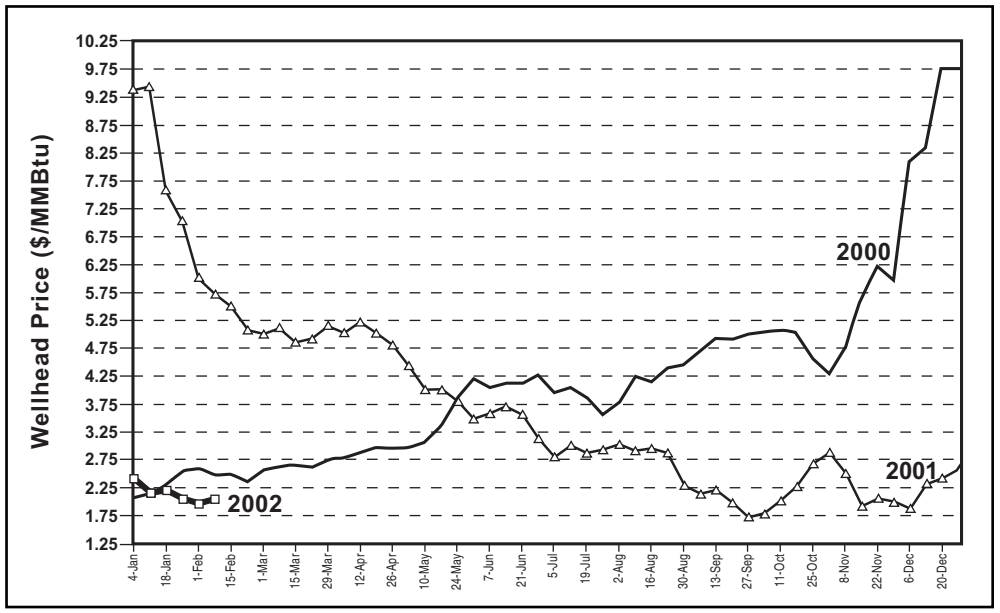


Figure 6. Natural gas 12-region (national) composite spot wellhead prices, Jan. 2000–Feb. 2002 (UBS Warburg LLC, NatGas Insight, Feb. 14, 2002, p. 4).

Crude Oil

A slow, overall decline in oil production in Colorado has occurred from a high of 39.5 million barrels of oil (MMBO) in 1977 (Figure 7). The graph on Figure 7 shows the trend of oil production in the state for the past 25 years.

Production numbers and values for 2000 in Colorado are summarized below for crude oil:

- 19.1 MMBO (0 percent from 19.1 MMBO in 1999);
- $537 million (+16.7 percent from $460 million in 1999).

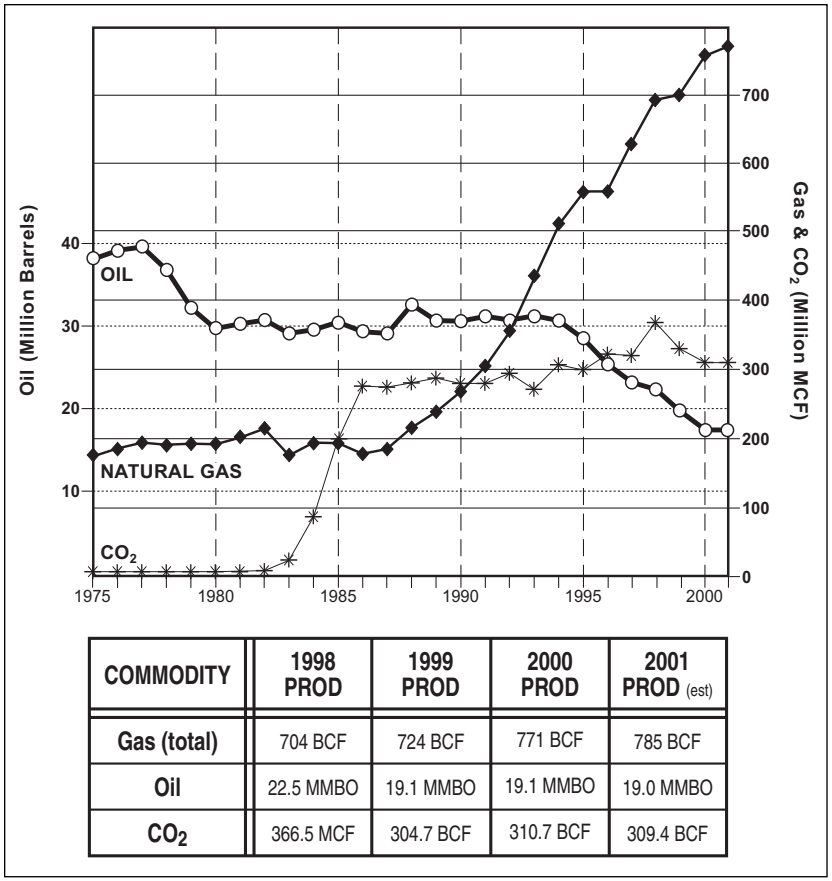
Estimated production numbers and values for 2001 in Colorado are summarized below for crude oil:

- 19.0 MMBO, (-0.5 percent from 2000);
- $441 million, value is down 18 percent from 2000 due to lower crude oil prices.

(Data from the Colorado Oil and Gas Conservation Commission)

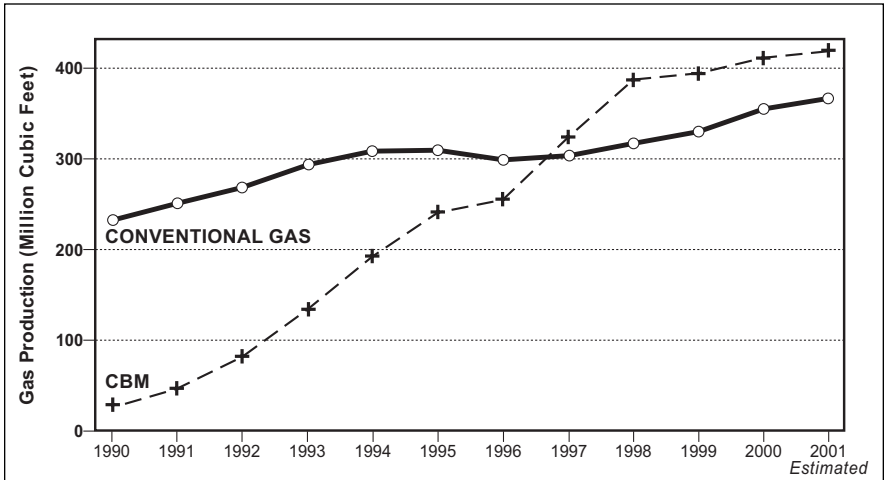
Carbon Dioxide

Annual carbon dioxide (CO_2) production for 2000 totaled 310.7 BCF, a 2 percent increase over the 1999 total of 304.7 BCF (Figure 7). Higher crude oil prices may



COMMODITY	1998 PROD	1999 PROD	2000 PROD	2001 PROD (est)
Gas (total)	704 BCF	724 BCF	771 BCF	785 BCF
Oil	22.5 MMBO	19.1 MMBO	19.1 MMBO	19.0 MMBO
CO_2	366.5 MCF	304.7 BCF	310.7 BCF	309.4 BCF

Figure 7. Colorado annual natural gas, oil and carbon dioxide production, 1975–2001.



PRODUCTION	1999	2000	2001 (est)
CBM	394 BCF	410 BCF	420 BCF
Conventional Gas	330 BCF	359 BCF	365 BCF

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

have been responsible for increases in secondary recovery efforts that used CO_2 injection. The total value to the state from CO_2 production in 2000 was $99.1 million, an increase of 3.1 percent from final 1999 numbers reported by the COGCC.

Estimated production numbers and values for 2001 in Colorado are summarized below for CO_2:

- 309.4 BCF, production projected to be flat with 2000;
- $99.1 million, value is projected to be flat with 2000.

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 10-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 after the reporting commenced, CBM production surpassed that of conventional natural gas in Colorado.

In 2000, 53 percent, or 410 BCF of the total 771 BCF of natural gas produced in Colorado came from CBM wells. Nationwide, CBM was produced from over 20,000 wells, accounting for 7.2 percent of the total U.S. natural gas production in 2000. CBM reserves in the U.S. are estimated at 15.7 trillion cubic feet (TCF) or 8.9 percent of the U.S. dry natural gas reserves of 177.4 TCF. This estimate for 2000 represents an 18.9 percent increase over the 1999 reported CBM reserves of 13.2 TCF in the U.S., and more than a four-fold increase over the 1989 estimated reserves of 3.7 TCF (U.S. DOE/EIA, 2001).

Coalbed methane (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 un-conventional 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 wellbore, 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, there is ample data that 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 9 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 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

Figure 9. Naturally occurring methane gas seeps causing bubbles in the Little Snake River in northern Colorado near the Wyoming border (photo by Laura Wray).

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 11). 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.

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 U.S. 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).

Oil production in Colorado began to decline from a high of 39.5 MMBO in 1977 (Figure 7). There were no major discoveries made 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 though 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.

Figure 10. Surface pumping unit (pumpjack) on an Upper Cretaceous coalbed methane well (photo by Laura Wray).

Natural gas has become an increasingly important commodity in both Colorado and the U.S. 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. 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.

Figure 11. Coalbed methane well surface equipment (i.e, Christmas tree), La Plata County, Colorado (photo by Laura Wray).

Coalbed methane (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 re-cently in the Sand Wash Basin. 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 about to commence 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, discriminates 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 between the four major CBM-producing areas in the U.S. from 1989 through 2000. Three states (Colorado, New Mexico, and Alabama) constitute three of the four areas. An "others" category includes CBM production from Wyoming, Utah, Oklahoma, West Virginia, Pennsylvania, Virginia, Kansas, and Montana. The bulk of the production from this group of states is from Wyoming's Powder River Basin where CBM activity during the past several years has risen sharply.

For the second year in a row, Colorado holds first place in total proved CBM reserves, widening the gap significantly from second place New Mexico which held the lead in proved CBM reserves for the past decade (Table 1). Whereas Colorado's gain in CBM reserves from 1999 to 2000 jumped 16.4 percent, the "others" category increased 40.1 percent, largely due to the explosion of drilling and production in Wyoming's Powder River Basin. It is only a matter of time before the combined contributions of states in the "others" category surpass Colorado in total CBM reserves.

Table 1. U.S coalbed methane proved reserves and production, 1989–2000 in billion cubic feet at 14.73 pounds per square inch absolute and 60° F (from Energy Information Administration, *2000 Annual Report*, p.35). *Note:* EIA production values for Colorado differ from COGCC values.

YEAR	COLORADO		NEW MEXICO		ALABAMA		OTHERS*		TOTAL	
	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production
1989	1,117	12	2,022	56	537	23	0	0	3,676	91
1990	1,320	26	2,510	133	1,224	36	33	1	5,087	196
1991	2,076	48	4,206	229	1,714	68	167	3	8,163	348
1992	2,716	82	4,724	358	1,968	89	626	10	10,034	539
1993	3,107	125	4,775	486	1,237	103	1,065	18	10,184	752
1994	2,913	179	4,137	530	976	108	1,686	34	9,712	851
1995	3,461	226	4,299	574	972	109	1,767	47	10,499	956
1996	3,711	274	4,180	575	823	98	1,852	56	10,566	1,003
1997	3,890	333	4,351	597	1,077	111	2,144	70	11,462	1,111
1998	4,211	387	4,232	571	1,029	123	2,707	99	12,179	1,180
1999	4,826	432	4,080	582	1,060	108	3,263	130	13,229	1,252
2000	5,617	451	4,278	550	1,241	109	4,572	269	15,708	1,379

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

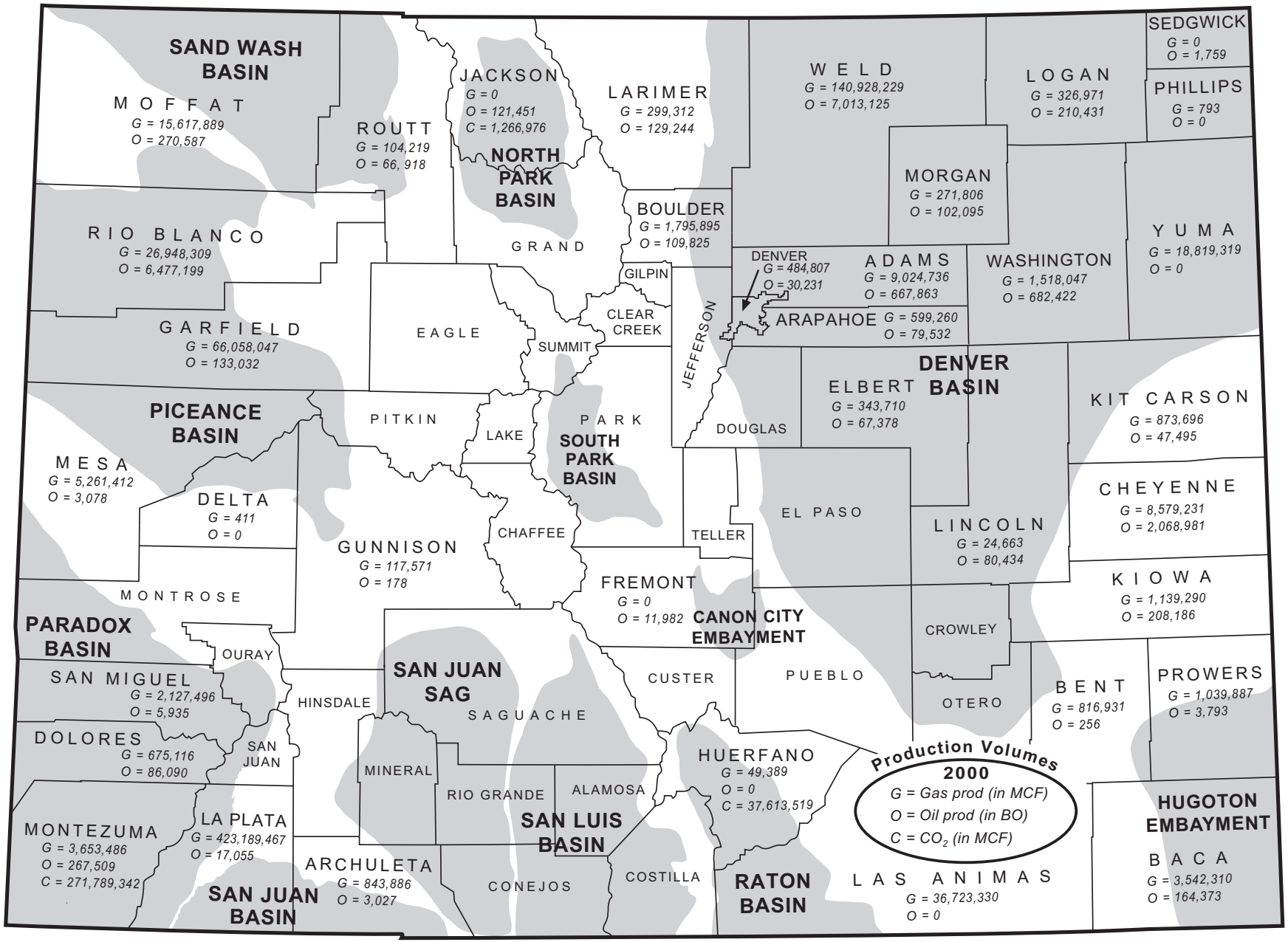


Figure 12. 2000 production volumes for Colorado Counties (data from COGCC).

Annual production of carbon dioxide (CO_2) had been on a several year decline until 2000 when the trend was reversed (Figure 7). CO_2 production rose 2.0 percent to 310.7 BCF in 2000. The forecast for 2001 is for a similar volume of production (COGCC). No new reservoirs have been discovered and 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-four (or 53 percent) of Colorado's 64 counties produced natural gas including CBM. Figure 12 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 2000 were the same as in 1999 (Table 2). La Plata County is still number one in gas production.

The bulk of the natural gas production in 2000 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 13 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.

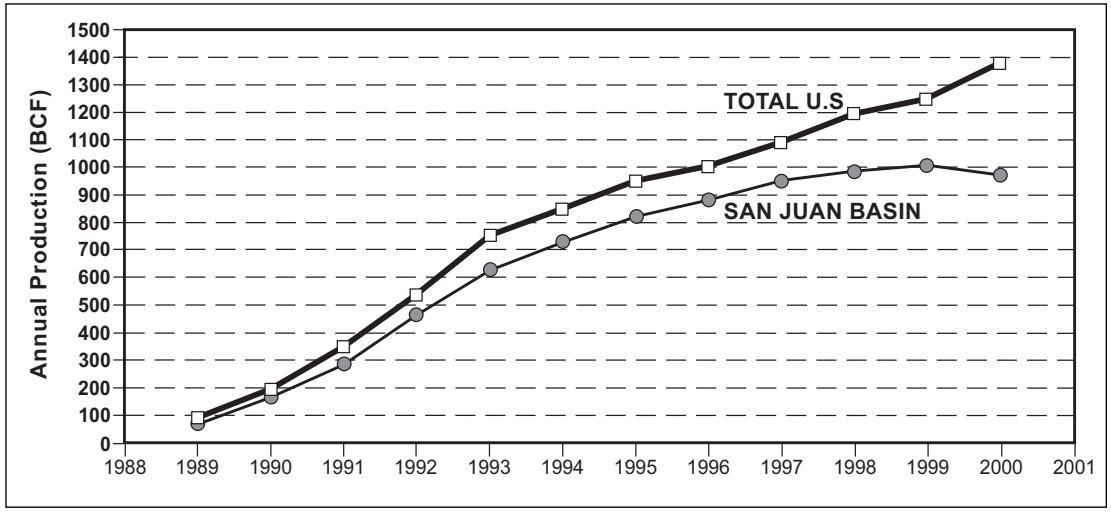


Figure 13. Comparison of the annual CBM production for the San Juan Basin (Colorado and New Mexico), and the entire U.S., 1998–2000. **Note:** The San Juan Basin production appears to have peaked in 1999, whereas U.S total CBM production continues to increase (Energy Information Administration—EIA, 2001; Petroleum Technology Transfer Council—PTTC Regional Review, *San Juan Newsletter*, October 2001).

Major reservoirs in Weld County included the Lower Cretaceous Muddy (J) and D sandstones of the Dakota Group as well as the Niobrara Formation carbonates (Table 2). The Late Cretaceous Williams Fork Formation sandstones in Garfield County accounted for the vast majority of that county's gas production in 2000 (Table 2).

In Colorado, 31 of the 64 counties contributed to 2000 oil production (Figure 12). The letter "O" on Figure 12 precedes production values for oil. The top three oil-producing counties in 2000, 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 achieved the number one oil production slot as a result of a major "refracing" effort that took place in the Denver Basin during 2000. Weld County production was derived predominantly from the Lower Cretaceous Muddy (J) and Codell sandstones, the Niobrara Formation carbonates, and the Sussex and Shannon sandstones.

Table 2. Top three counties in Colorado in 2000 for annual production of natural gas (including CBM). Cumulative production for each county shown as well (data from COGCC). (MCF = thousand cubic feet)

RATING	COUNTY	ANNUAL GAS PRODUCTION (MCF)	PERCENT OF ANNUAL COLO. PRODUCTION	CUM. GAS PRODUCTION (MCF)
1	La Plata	423,183,593	55	3,835,183,593
2	Weld	140,310,857	18	2,278,944,212
3	Garfield	65,813,234	8.5	526,256,619

Table 3. Top three counties in Colorado in 2000 for annual production of crude oil. Cumulative production for each county shown as well (data from COGCC). (BO = barrels of oil)

RATING	COUNTY	ANNUAL OIL PRODUCTION (BO)	PERCENT OF ANNUAL COLO. PRODUCTION	CUM. OIL PRODUCTION (BO)
1	Weld	6,930,103	36	197,490,338
2	Rio Blanco	6,467,395	34	941,930,700
3	Cheyenne	2,068,481	11	78,938,080

Oil production in Rio Blanco County came primarily from the Permo–Pennsylvanian Weber Sandstone in Rangely Field. Cheyenne County oil production came primarily from the Mississippian and Pennsylvanian sandstone and limestone reservoirs.

In terms of carbon dioxide production, Montezuma County contributed 272 BCF, a full 88 percent of the state's total CO_2 volume in 2000.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 12 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.

Production numbers for 2001 by individual counties are not available at this time.

Consumption

An impressive 84 percent of natural gas consumed within the U.S. is produced in this country. In contrast, only 45 percent of crude oil consumed in the U.S. is produced domestically. Gas currently accounts for approximately 16 percent of the total U.S. electrical generation. Colorado's natural gas consumption by sector in 2000 is shown numerically in Table 4 and graphically in Figure 14. Colorado became a net exporter of natural gas for the first time in 1991.

Refined crude oil consumption in 1999 is displayed in Table 5. To see how important both gas and oil are to total energy consumption in Colorado, refer to Figure 15. 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 energy consumption.

Commodity Pricing Value

In 2001, the total value for natural gas (including CBM), crude oil, and carbon dioxide in Colorado is estimated at $3.21 billion (Table 6), equal to the final tallied number for 2000. Whereas production volumes are expected to be higher for most petroleum commodities in 2001, the lower commodity prices will offset those gains. Hence, the net resulting value for all of them is expected to be approximately the same as in 2000 (COGCC).

Monthly wellhead prices from 1998 through 2001, shown in Figure 16a, characterize the price volatility that can and does affect the petroleum industry and its consumers. The wellhead price index for natural gas was extremely volatile during the years 2000 and 2001. By comparison, Figure 6 shows the national composite spot wellhead prices for natural gas on a national basis during the same time period. The trends are practically identical for Colorado and the entire U.S. Even a simplified accounting of gas and oil prices in Colorado, calculated on a yearly basis by mid-year (shown in the following table), reveals the overall downward trend that has occurred since the middle of 2001:

Table 4. Colorado consumption of natural gas by sector in 2000 (Energy Information Administration, 2001). (BCF = billion cubic feet)

SECTOR	2000 NATURAL GAS CONSUMPTION (BCF)	PERCENT OF TOTAL NATURAL GAS PRODUCTION
Residential	116	15.4
Industrial	90	12.0
Commercial	61	8.1
Lease, Pipeline & Plant Fuel	46	6.1
Electric Utilities	32	4.3
Export Out of State	407	54.1
TOTAL	**752**	**100**

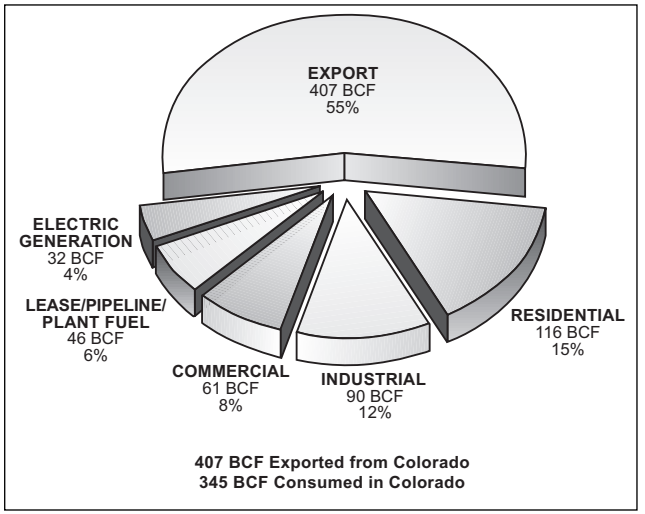


Figure 14. Colorado natural gas consumption by sector, 2000 (EIA, 2001). (BCF = billion cubic feet)

Table 5. Colorado consumption of refined crude oil by source in 1999 (EIA, 2001). (BO = barrels of oil)

TYPE OF USE	1999 CONSUMPTION (BO)	PERCENT OF TOTAL CONSUMPTION
Asphalt & Road Oil	2,137,000	2.9
Aviation Gasoline	195,000	0.26
Diesel	16,275,000	21.9
Jet Fuel	7,800,000	10.5
Kerosene	32,000	0.04
Lubricants	79,000	0.9
Motor Gasoline	47,069,000	63.4
Residual Fuel	4,000	0.005
TOTAL	**74,191,000**	**99.9**

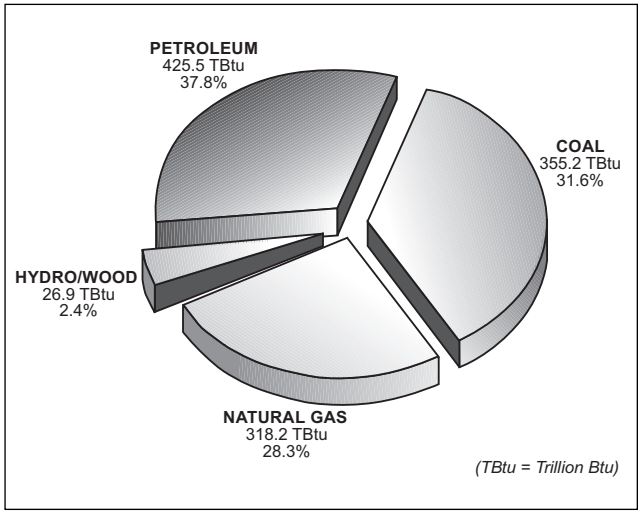


Figure 15. Energy source consumption in Colorado, 2000 (EIA, 2001).

Table 6. Value of hydrocarbon commodities in Colorado 1998–2001.

YEAR	VALUE OF NATURAL GAS & CBM (in million $)	VALUE OF CRUDE OIL (in million $)	VALUE OF CO_2 (in million $)	TOTAL VALUE (in million $)
1998	1,375	285	85	1,745
1999	1,490	334	85	1,909
2000	2,580	537	99	3,216
2001(e)	2,660	441	99	3,200

(e) = estimated

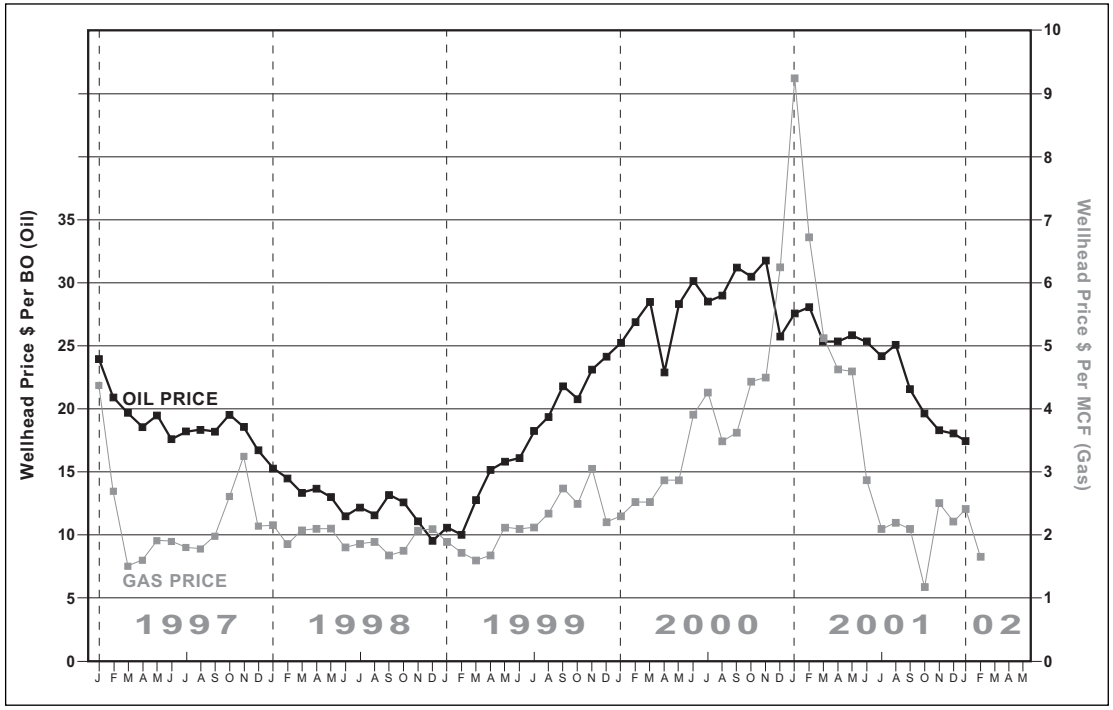


Figure 16a. Colorado gas and oil monthly wellhead price index 1997 through first quarter 2002.

TIME	GAS PRICE ($/MMBtu)*	OIL PRICE ($/Bbl)**
July 2000 to June 2001	$4.74	$28.12
July 2001 to Feb. 2002	$2.07	$20.87

*Colorado Weighted Average Price for Gas
**Colorado Weighted Average Composite Index for Crude Oil (from COGCC)

Drilling Permits and Drilling Activity

Continuing a second year of growth, the number of drilling permits or "APDs" (Applications for Permit to Drill) in Colorado rose to 2,273 in 2001, a new yearly high for the past decade. This was a 49 percent increase over the 2000 total of 1,529 APDs (Figure 16b). Higher gas prices at the end of 2000 spilled over into the first few months of 2001, prompting this surge in applications, the vast majority of which were for natural gas and CBM wells.

Two factors are responsible for the COGCC's estimate of 1,900 APDs in 2002: 1) only 50 percent of the APDs approved in 2001 were actually drilled and since these APDs are in effect for one year, companies will likely de-emphasize new permits in 2002, choosing instead to drill approved ones; and 2) the low price scenario may likewise discourage both old and new APDs in 2002.

In 2001, the top 5 counties from which the most APDs were submitted were: Weld County (702), Las Animas County (400),

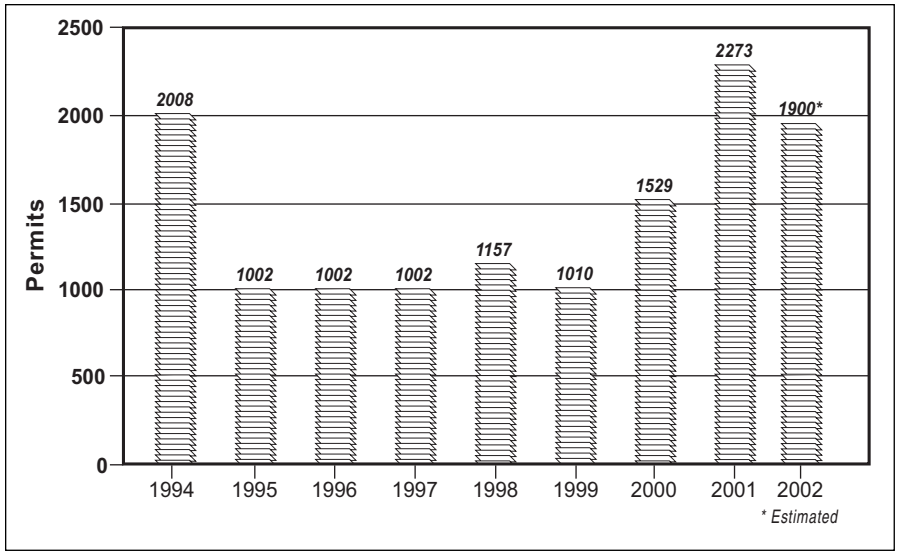


Figure 16b. Colorado drilling permits, 1994–2002 (COGCC).

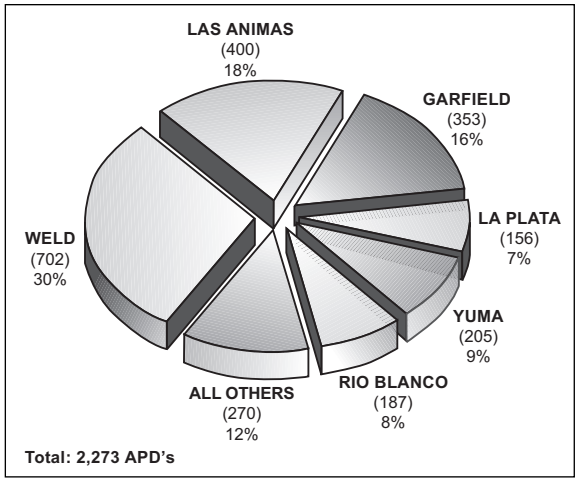


Figure 17. Colorado oil and gas 2001 drilling permits through December 31, 2001 (COGCC).

Garfield County (353), Yuma County (205), and Rio Blanco County (187) (see Table 7). Figure 17 shows a pie chart with these 2001 drilling permit statistics. Note that La Plata County, ranked number six on Figure 17, is not included in Table 7 in 2001. La Plata County had been in the top five counties for APDs for the previous three years but fell to sixth place in 2001.

Table 7. Top five Colorado counties submitting drilling permits (APDs) in 2001 (COGCC).

YEAR	NUMBER 1	NUMBER 2	NUMBER 3	NUMBER 4	NUMBER 5	TOTAL APD's
1998	Weld 392	Las Animas 195	Yuma 111	Garfield 95	La Plata 82	1,157
1999	Weld 340	Las Animas 195	Garfield 131	La Plata 118	Rio Blanco 100	1,010
2000	Weld 509	Las Animas 268	Garfield 213	La Plata 127	Rio Blanco 89	1,529
2001	Weld 702	Las Animas 400	Garfield 353	Yuma 205	Rio Blanco 187	2,273 (+49%)

A brief synopsis of the 2001 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 wellbore). The major hydrocarbon reservoirs in Weld County are the Lower Cretaceous "D" and Muddy (J) sandstones, Upper Cretaceous Codell sandstones, and Niobrara Formation limestones.

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.

In Garfield County, activity focused on the Upper Cretaceous Williams Fork Formation tight (low permeability) sandstones and upon the coals of the Mesaverde Group.

Yuma County, ranked 4th in 2001 replacing La Plata County, showed a 561 percent

increase from the previous years of only 31 APDs to 205 APDs in 2001. Upper Cretaceous Niobrara Formation biogenic gas development was responsible for most of the 2001 activity.

Finally, the 5th place county for APDs in 2001 was Rio Blanco County where Permo–Pennsylvanian Weber Sandstone permits were joined by permits for Upper Cretaceous Mesaverde Formation sands and coals, sands in the Mancos Shale, and Tertiary Wasatch Formation coals and sands.

A break-down of wells drilled in Colorado in 2000 and 2001, compared to those drilled in the Rocky Mountain region and in the total U.S. over that two-year period, is shown on Table 8. All three areas show the following trends for both 2000 and 2001: 1) development wells exceed exploratory wells by a factor of approximately 10 to 1; 2) gas wells drilled greatly exceeded oil wells drilled; 3) Colorado's low percentage of dry holes (6 percent in 2000 and 8 percent in 2001) compared favorably with Rocky Mountain statistics of 5.6 percent and 5 percent, and was extremely impressive when compared to the national numbers of 15 percent and 13 percent in 2000 and 2001 respectively (Petrol. Info./Dwights LLC d\b\a IHS Energy Group, 2002).

Daily national rig counts decreased by 18 percent to 907 active onshore and offshore rigs in 2001, down from 1,107 rigs in 2000 (*Oil and Gas Journal*, 2002). In the 11-state Rocky Mountain region, the rig count at the end of 2001 was 137 as compared to a total of 193 at the end of 2000. IHS Energy Group estimates that the average number of rigs for 2001 in Colorado was 44. Figure 18 shows the percentages of active wells by counties for 2001. Figure 19 is a bar chart that displays the monthly rig count in Colorado in 2001. Note how similar the trend is for Colorado's 2001 rig count on Figure 19 and the 2001 U.S. rig count seen on Figure 20.

Colorado and Rocky Mountain operators were unable to contract enough rigs and rig crews to drill all the permitted locations obtained in 2001. There continues to be only a finite number of rigs and rig crews that can meet the fluctuating demand. As the number of wells drilled falls in response to lowered prices, rig crews are laid off and rigs are stacked.

Employment Statistics

The Colorado Department of Labor and Employment projected approximately 7,851 jobs in 2000 for the oil and gas extraction sector of the petroleum industry in Colorado, an increase of about 650 jobs from 1999. It is difficult to estimate employment numbers in 2001. Whereas

Table 8. Types of wells drilled in 2000 and 2001 for Colorado, Rocky Mountain region, and Total U.S. (Petroleum Information/Dwights LLC d\b\a IHS Energy Group, 2002).

	1	2	3	4	5	6	7	8
REGION & YEAR	DEVELOPMENT WELLS	EXPLORATION WELLS	DRY HOLES	GAS WELLS	CBM WELLS (inc. in Col. 4)	OIL WELLS	HORIZONTAL WELLS	TOTAL WELLS DRILLED = Cols. 1 + 2 = Cols. 3 + 4 + 6
Colorado – 2000	**799**	**65**	**55**	**761**	**204**	**48**	**3**	**864**
Rocky Mtns. – 2000	5,564	407	327	5,171	3,361	473	165	5,971
Total U.S. – 2000	22,088	2,187	3,697	13,589	3,737	6,989	1,038	24,275
Colorado – 2001	**859**	**76**	**80**	**828**	**128**	**27**	**2**	**935**
Rocky Mtns. – 2001	6,043	456	302	5,684	3,559	513	216	6,499
Total U.S. – 2001	24,503	2,478	3,550	16,257	4,096	7,174	1,009	26,981

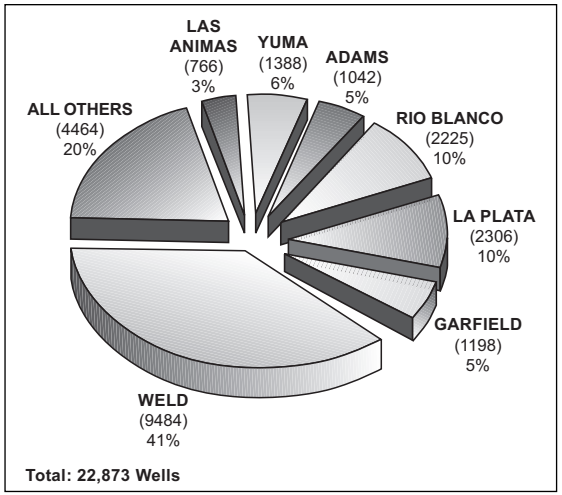


Figure 18. Active wells in Colorado counties, 2001 (data from COGCC).

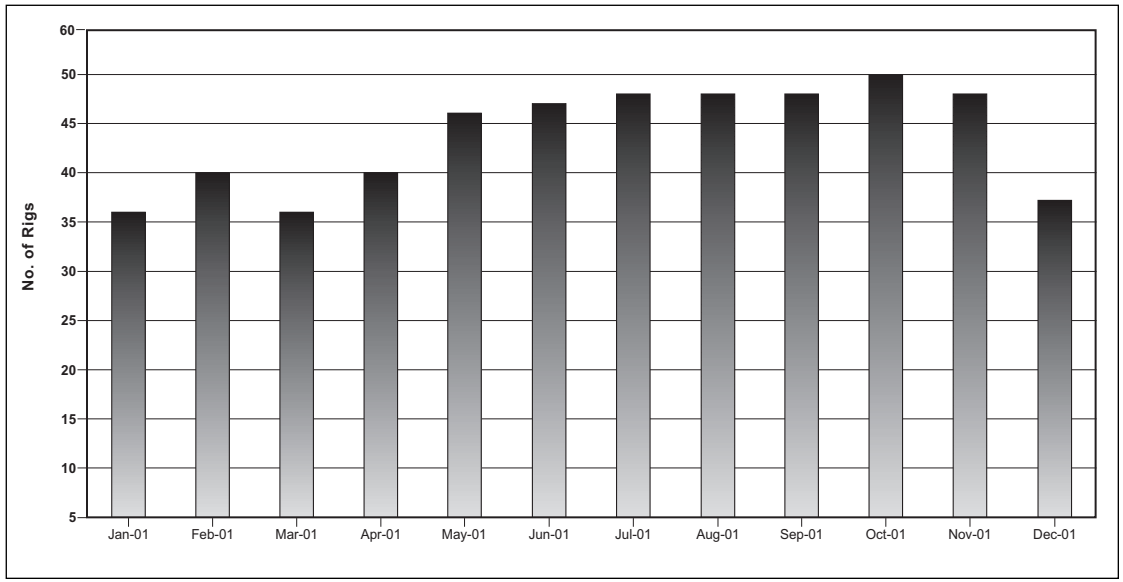


Figure 19. Colorado average monthly rig count (IHS Energy Group), 2001.

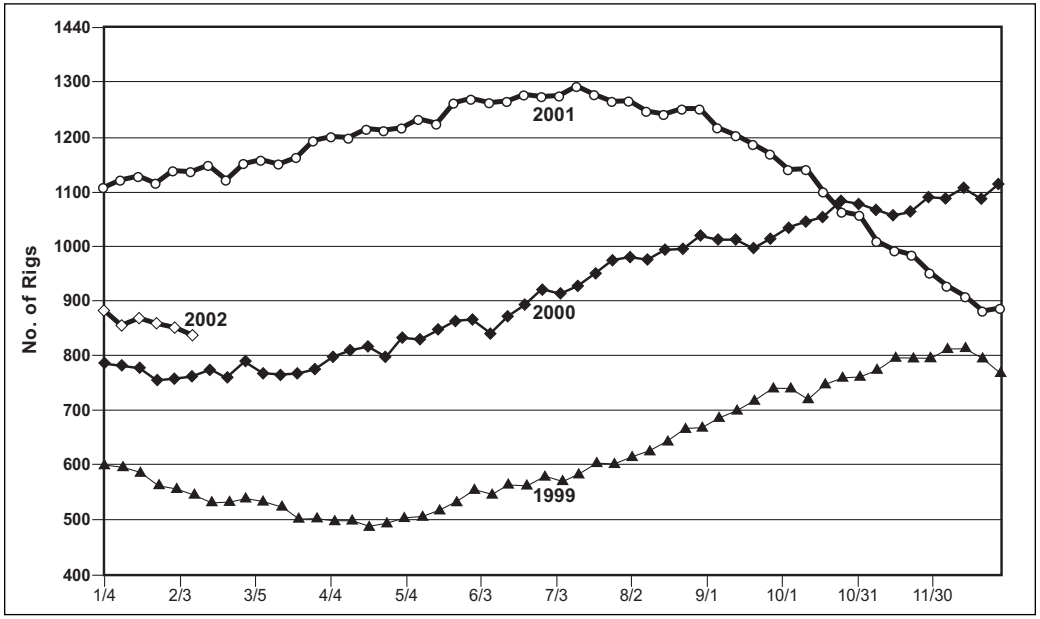


Figure 20. U.S rig count (Baker Hughes, Inc.).

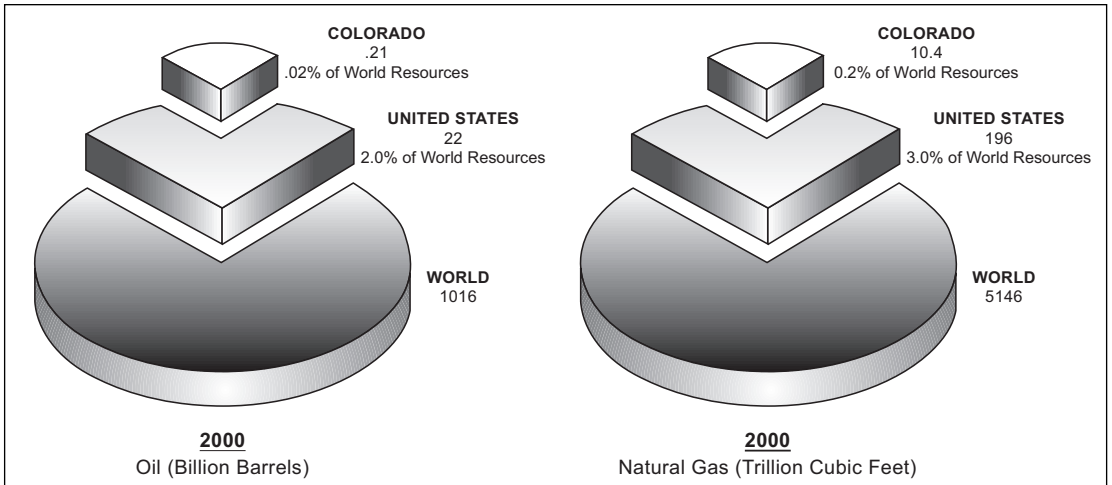
the first half of the year probably posted a net gain in employees due to high gas and oil prices, the rapid fall in commodity prices coupled with an economic decline in the last half of the year may have completely offset that gain.

The Colorado Oil and Gas Association (COGA) calculates some different employment numbers (COGA report entitled *Clear Energy for Colorado and America—The Role of Colorado and the Rockies to Power the New Economy*, December 2001). This report lists the direct numbers of jobs provided in the petroleum industry in Colorado as 11,510 people.

Reserves

Colorado

Proved dry natural gas reserves in Colorado were estimated at 10,428 BCF at the end of 2000, a 16 percent increase from the 1999 total of 8,987 BCF. This volume accounts for 21.7 percent of the Rocky Mountain region's proved gas reserves. Colorado is ranked seventh in the U.S. in proved dry natural gas reserves. Of the approximate 196 TCF of proved reserves for U.S. natural gas, the Rocky Mountain region, which includes Colorado, comprises 27 percent of those reserves (Figure 21a). Figure 21b, 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,



	2000			2001	2002
	Colorado	United States	World	World	World
Oil (Billion Barrels)	.21	22	1016	1028	1031
Natural Gas (Trillion Cubic Feet)	10.4	196.4	5146	5278	5451

Figure 21a. Total U.S natural gas *proved* reserves in trillion cubic feet (DOA/EIA).

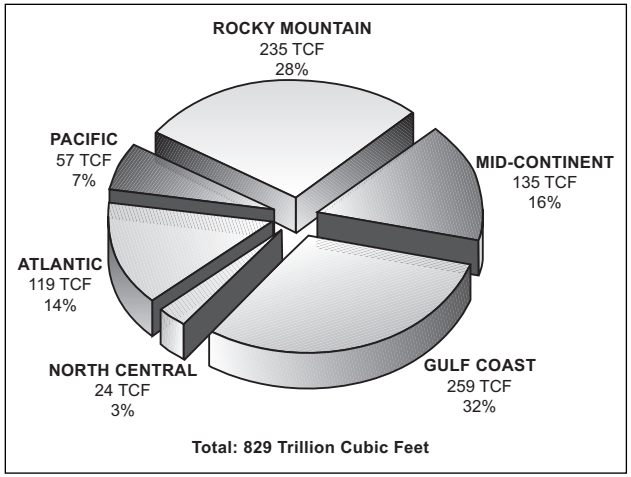


Figure 21b. Estimates of *potential* gas resources, 2000 (source: Potential Gas Committee).

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 217 MMBO at the end of 2000, up 2 percent from the 1999 total of 212 MMBO. Colorado's crude oil reserves constituted 12 percent of the total reserves in the Rocky Mountain region and just 1 percent of the nation's proved crude oil reserves at the end of 2000. Colorado was ranked 11th in U.S. proved crude oil reserves in 2000.

United States

In December 2000, the U.S. proved reserves of dry natural gas were 196,400 BCF (196 TCF), an 11 percent increase from the 1999 total of 167,406 BCF. The U.S. total discoveries of dry natural gas were up 4,341 BCF in 2000. Year end 2000 U.S. proved reserves of crude oil were 22.05 billion barrels of oil (BBO), a 1 percent increase from 21.77 BBO in 1999. In the U.S., crude oil production was replaced 115 percent by the identification of new reserves.

World

World gas reserves in 2001 grew to 5,278 TCF, up 2.6 percent from the published 2000 world gas reserves of 5, 146 TCF (*Oil and Gas Journal*, Dec. 24, 2001). World oil reserves climbed to 1.028 trillion barrels in 2001, up 1 percent from the 2000 world oil reserves of 1.016 trillion barrels. The projections for world oil reserves are estimated to be 1.031 trillion barrels in 2002. OPEC reserves account for 79.4 percent of the total world oil reserves and 46 percent of the total world gas reserves (*Oil and Gas Journal*, Dec. 25, 2001, p. 125).

News and Developments

Mergers and Acquisitions

Merger-mania that affected the mega-companies such as Amoco, Arco, Exxon, Mobil, British Petroleum, Texaco, and Chevron, as well as the medium majors such as Phillips, Union Pacific, Anadarko, El Paso, Marathon, and Coastal, began in earnest in 1998 and continued through 2001. Large, medium, and small independent companies joined the merger and acquisition fray in 1999 and consummated some significant deals in 2000 and 2001. Table 9 shows a list of some of the mergers, acquisitions, and joint ventures that affected companies active in Colorado. These strategies were developed to reduce costs between two companies, achieve business and financial efficiencies, combine resources and expertise, maintain a

Table 9. Acquisitions (A), Mergers (M), and Joint Ventures (JV) in 2001 affecting petroleum companies with operations in Colorado.

COMPANIES INVOLVED	PRICE TAG ($ million)	STRATEGY
Chevron – Texaco (M)	$35,000	Create Chevron Texaco, the second largest major petroleum company, with $77 billion of assets; 11.2 billion barrels of oil equivalent reserves; and 2.7 million barrels of oil equivalent daily production. (1)
Kerr McGee – H. S. Resources (A)		Acquire major interest in the gas and oil fields of Colorado where increased density drilling, refracs, and deepenings have added reserves.
Shell Oil – McMurray Energy (A)		Acquire working interest in one of the most significant basin-centered gas plays in the U.S., Jonah Field, in Wyoming.
Stone Energy – Basin Exploration (M)	$410	Combine proved reserves (1999) of 598.9 BCF equivalent. (1)
Key Production – Columbus Energy (A)	$32.2	Acquire 18 BCF equivalent reserves. (1)
Pure Oil – Hallwood Energy (A)		Acquire CBM properties. (2)
Alberta Energy Co., Ltd. – Ballard Petroleum, LLC (A)	$225	Acquire producing properties in Mamm Creek Field, Piceance Basin, Garfield, Colorado
Valero Energy Corp. – Ultramar Diamond Shamrock Corp. (A)	$4000	Will create second largest oil refinery in the U.S. Valero will obtain 7 refineries and nearly 5,000 gas stations.
Westport Resources Corp. – Belco Oil & Gas Corp. (M)	$922	Westport gets $334 million in stock and $588 million in assumed debt. Belco shareholders get 2 seats on the Board of Directors and will control 26% of Westport's shares. (2)
Cabot Oil & Gas – Cody Co. (A)	$230	
Evergreen Resources, Inc. – J. M. Huber (JV)		Evergreen acquires 50% working interest in >29,000 acres in Huerfano County and must commit to $2 million to drill ~10 CBM wells. (3)
Evergreen Resources, Inc. – Shenandoah (A)	$19.2	Evergreen acquired 35% working interest in ~17,000 acres in southern Raton Basin. (3)

(1) Oil and Gas Investor.com, April 2000 (2) Denver Post (3) A. G. Edwards' report on Evergreen Resources, Inc., July 26, 2001

competitive edge with all the other merged companies, and, in general, grow the joint resource bases.

Forecasts

At the beginning of 2002, natural gas prices continued to be low, a fact that pleased the downstream consumers and worried the upstream suppliers. A warmer than expected winter lessened the demand nationwide for fuels to generate electricity and heat. The travel industry failed to achieve a significant rebound after September 11th, causing diminished demand for aviation fuel and gasoline. It was actually not until early March 2002 that gas prices inched up above $2.00/MCF and then above $3.00/MCF, raising industry hopes that another recovery had begun.

The COGCC estimates that the overall value to the state in 2001 from petroleum operations will be close to what it was in 2000, but that values will drop by 49 percent in 2002 (see Figure 5). Actual production volumes are forecasted to rise modestly in 2001 for natural gas and CBM and remain flat for crude oil and CO_2. We can expect lower prices for natural gas and crude oil, whereas prices for CO_2 may stay stable.

The slow recovery that appears to be taking place in the first quarter of 2002 makes us more optimistic about the health of the industry by year end. Modest gas price increases, coupled with soon-to-expire APDs, should prompt drilling in the second and third quarters of 2002.

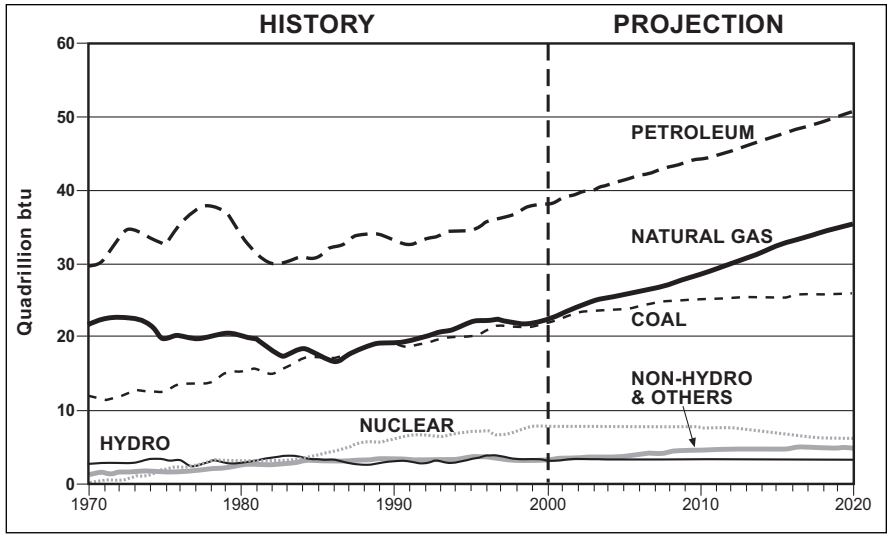


Figure 22a. U.S. Energy consumption by fuel, 1970–2020 (DOE/EIA).

Assuming that prices do not fall again to the 2001 year end levels, we can expect employment numbers to rise slightly after falling in response to lowered gas and oil prices. In short, we believe that the industry will experience a slight rebound in 2002, though not of the magnitude seen in 2000.

Renewable Energy Resources

The price fluctuations, supply constraints, and electrical generation shortages that plagued 2000 and 2001 were already a concern to energy consumers before September's terrorist attacks heightened the awareness of energy vulnerability. A growing interest in renewable energy resources was reborn.

"Renewable energy" is defined as energy obtained from sources that are essentially inexhaustible. The five primary renewable energy sources in the United States include: hydroelectric power (46 percent of total renewable energy produced in the U.S.), wood (38 percent), waste (8 percent), geothermal (5 percent), alcohol fuels (2 percent), solar (1 percent) and wind (1 percent). Figure 22a presents a graphical comparison of energy consumption by hydroelectric power and non-hydroelectric renewables as compared to energy consumption by petroleum, natural gas, coal, and nuclear sources from 1970-2020.

Focusing on Colorado, renewable energy constitutes just 2.5 percent of the total energy consumption in the state. Figure 22b shows the graphical relationship of renewable energy to petroleum, natural gas, coal, and nuclear electric power and also sub-divides the contributions to renewable energy.

In 2000, renewables accounted for almost 7 percent of total U.S. energy consumption. The use of renewable energy is projected to grow an average of 1.1 percent per year through 2020, compared to 1.3 percent for nonrenewables. Most of the growth in renewables will probably be due to mandates and incentives.

Only a modest amount of growth in Colorado for renewables is expected in the foreseeable future. The larger utility companies that voluntarily offer "green" power (generated by renewable sources) as an option to consumers will drive most of this growth. This green power is primarily produced by either wind or solar. More mature forms of renewable energy include hydropower and landfill gas (methane) that are already part of the standard power generation mix. Other forms of renewable energy, such as geothermal, mixing biomass with coal (cofiring), and some types of solar technologies, are not yet used commercially for electric generation in Colorado.

Today, approximately 98 percent of Colorado's energy is produced by fossil fuels: coal, natural gas, and oil (Figure 22b). Colorado ranks 29th in overall U.S. energy consumption, 40th in per capita consumption, and 48th in total energy expenditures per person (source: EIA).

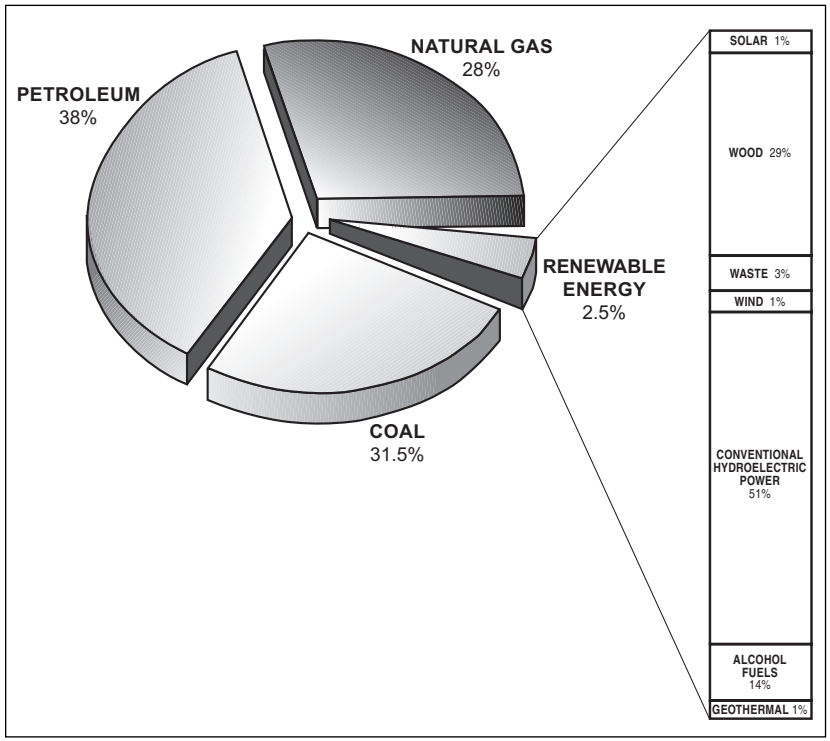


Figure 22b. Colorado renewable energy as share of total Colorado energy consumption by source, 2000 (EIA, 2000, Annual Energy Review).

Table 10. Glossary of terms.

GLOSSARY	
(A)	Acquisition
APD	A Permit to Drill
Bbl	Barrel (of oil)
BBO	Million barrels of oil
BCF	Billion cubic feet of gas (natural, CBM or CO_2)
BO	Barrel of oil
Btu	British Thermal Unit (see definition on page 23)
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 0's 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 Btu's
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

Table 11. Industry Web site links.

American Gas Association (AGA)	www.aga.org
American Petroleum Institute (API)	api.org
American Wind Energy Association	awea.org
Colorado Department of Local Affairs (DOLA)	dola.state.co.us/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

Compiled by Thomas Hyde, 2001, for COGA report entitled "Clean Energy for Colorado and America—The Role of Colorado and the Rockies to Power the New Economy," Dec. 2001, p.43.

COAL

By Christopher J. Carroll

Introduction

The Colorado coal industry marked 2001 as the best mining and production year ever. For the fourth time in five years, Colorado coal mines combined to set a new record for annual coal production. In 2001, more than 33.4 million short tons of coal were produced from 12 coal mines, a 15 percent increase over the previous year. The achievement was, in part, due to a national increase in coal usage at power plants to alleviate an impending energy crisis in California. The coal spot market price increased for the first time in 15 years. The power crisis was short-lived, and as fear of a deregulated energy market subsided, coal prices leveled off by year's end. Overall, the value of coal was realized as a stable market commodity for electricity generation.

As the population and its demand for electricity grows, so does coal consumption. As natural gas prices fluctuated in 2001, the demand for coal-fired electricity generation increased. This demand pushed coal prices upward. As coal stockpiles dwindled, operators responded by increasing production. The timing was right for Tri-State Generation and Transmission Association and its partners to announce plans for building a large coal-fired power plant in Colorado, the first such plant to be built in Colorado in two decades. They plan to build a $1.3 billion plant near Las Animas to supply 1,200 megawatts of electricity. This will help offset the large demand for natural gas power and will assist utilities to augment their power supply sources with alternatives. The advantage is that coal is a cheaper fuel than gas with less market volatility. The Las Animas plant may be operational by 2007.

Every economic factor in the Colorado coal industry saw increases in 2001. Nearly 1,800 miners were employed at the state's coal mines as of December 2001. Nationally, Colorado is now ranked as one of the top-ten coal producing states. The value of Colorado coal keeps rising with increased production. Using a price of $15 per ton, the value of coal produced in 2001 is $502 million.

One new mine opened in 2001, the Lorencito Canyon Mine in Las Animas County (Mine No. 2 on Figure 23). Owned by AEI Resources of Kentucky, this mine is currently a surface mine with long-term plans for underground mining. The company mines an 18 inch seam of 13,000 Btu, high volatile A, bituminous coal, and ships it by rail to the Tennessee Valley Authority for blending purposes at electric utility power plants.

Colorado's closest competitor, Wyoming's Powder River Basin, sells ten times as much coal and can mine 40–60 foot seams very inexpensively. Nearly 95 percent of Colorado coal sales were completed on the spot or short-term contract market last year, making it important to Colorado coal producers to be competitive in the spot market.

2001 Coal Supply

In addition to the new state coal production record, several mines also set individual production records in 2001. Five mines each surpassed their own annual output records: Bowie No.2, Deserado, McClane Canyon, Sanborn Creek, and the Seneca Strip mines (Figure 23 and Table 12). A combination of high coal demand and favorable longwall mining conditions without large work stoppages enabled record production. A record 23.6 million tons of coal were produced from seven underground mines and 9.8 million tons from the five surface mines. The Foidel Creek Mine, the most productive underground mine in Colorado, ranks as the fourth largest underground coal mine in the nation. Colowyo Mine, the largest surface mine in Colorado, is the 24th largest surface mine in the nation.

Coal was produced in nine Colorado counties last year (Figure 24). The three highest coal-producing counties were Routt, Gunnison, and Moffat Counties, which combined for 75 percent of the state's coal production. Routt County was again the leader with 9.43 million short tons produced. Gunnison County replaced Moffat County as the second leading coal producing county in the state last year. This was due, in part, to both Sanborn Creek and West Elk Mines maximizing coal production.

In regard to geologic coal regions, the large Uinta coal region was the leader by producing more than 21 million short

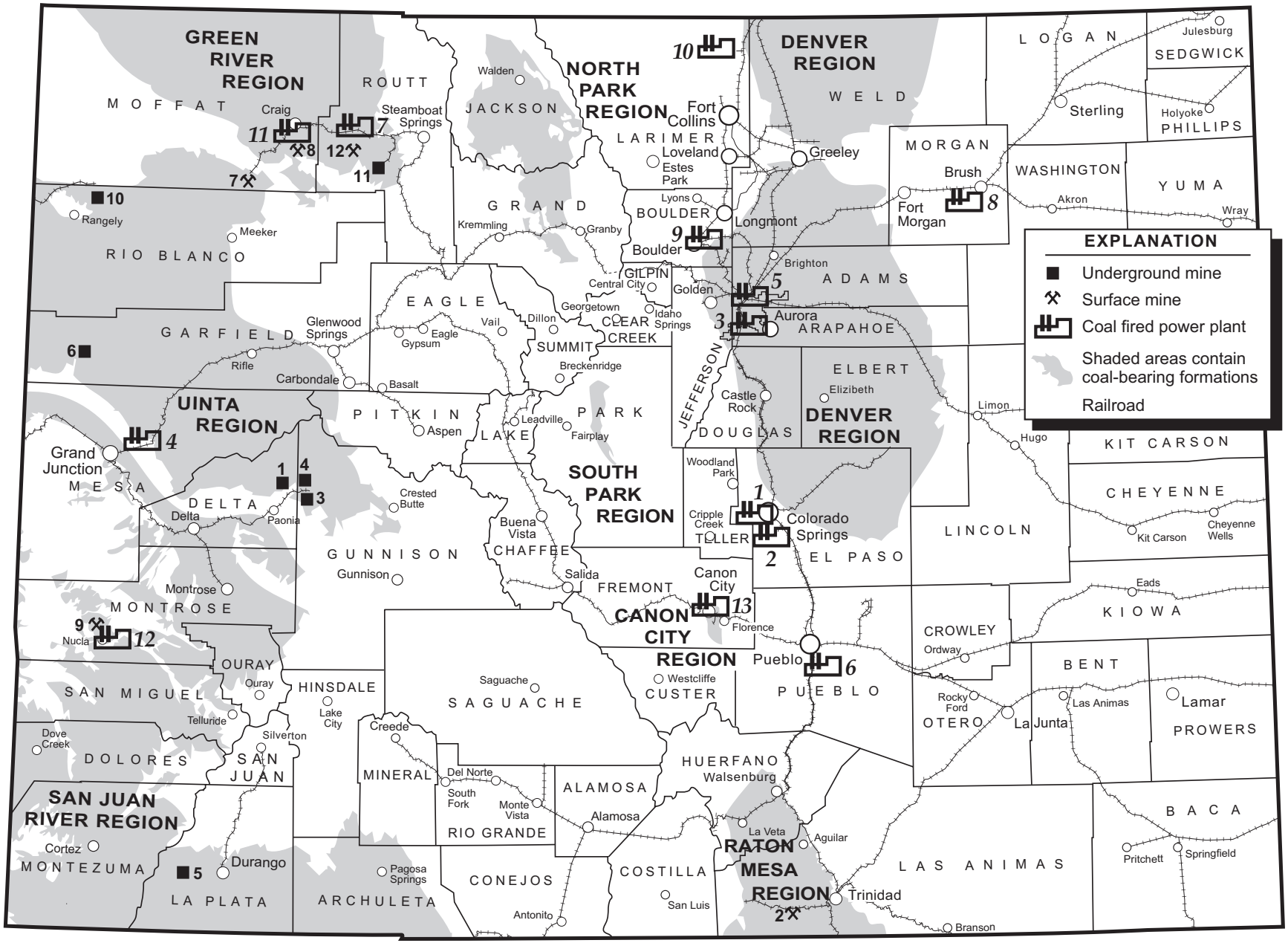


Figure 23. Map of Colorado coal mines and power plants (see Table 12 for mine names and Table 15 for power plant names).

Table 12. Colorado Coal mine statistics, 2001 (see Figure 23 for mine locations).

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	2001 PROD.* (tons)	DEC. 2001 MINERS	SHIPMENT METHOD
1	Bowie #2	Delta	Uinta	Somerset	Bowie Resources, Ltd.	13S, 91W	Mesaverde	D	9 – 12	11,800	U	Longwall, continuous	5,388,947	197	Truck, rail
2	Lorencito Canyon	Las Animas	Raton Mesa	Trinidad	Addington Brothers	34S, 66W	Raton	Na, M	1.5 – 4	13,000	S	Surface area	13,098	27	Rail
3	West Elk	Gunnison	Uinta	Somerset	Arch (ACI) Mtn. Coal Co.	13S, 90W	Mesaverde	B	14	11,650	U	Longwall, continuous	5,024,422	286	Rail
4	Sanborn Creek	Gunnison	Uinta	Somerset	Oxbow Mining, Inc.	13S, 90W	Mesaverde	B, C	18 – 25, 6 – 8	12,375	U	Longwall, continuous	2,859,560	203	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	264,676	50	Truck
6	McClane Canyon	Garfield	Uinta	Book Cliffs	Lodestar	7S, 102W	Mesaverde	Cameo B	4.4 – 9.4	11,250	U	Continuous	323,011	21	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	5,767,595	280	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.	1,942,311	114	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	370,725	20	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	2,027,341	160	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	7,709,874	348	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	1,719,365	93	Truck, rail
TOTAL													**33,410,925**	**1,799**	

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

Table 13. Coal production by coal region, 2001 (data from Colorado Division of Minerals and Geology).

COAL REGION	PRODUCTION	NUMBER OF MINERS (December 2001)	NUMBER OF MINES (Surface/Underground)	MINES
Green River	11,371,550	555	2/1	Foidel Creek, Seneca (Seneca II-W) and Yoast, Trapper
Raton Mesa	13,098	27	1/0	Lorencito Canyon
San Juan River	635,401	70	1/1	King Coal, New Horizon
Uinta	21,390,876	1,147	1/5	Colowyo, McClane Canyon, Deserado, Bowie #2, Sanborn Creek, West Elk
TOTAL	**33,410,925**	**1,799**	**5/7**	

tons from six mines (Table 13). Somerset was the most prolific coal field (Bowie No. 2, West Elk, and Sanborn Creek mines) at 13.27 million tons produced.

Colorado continues to produce coal at a high rate. At the end of the first quarter of 2002, Colorado positioned itself to be the 8th largest coal producing state in the nation, having recently surpassed Illinois in the national rankings. Coal production is 2 percent higher than at the same time last year. Coal sales have slowed in 2002, though, and many mines report excess stockpiles.

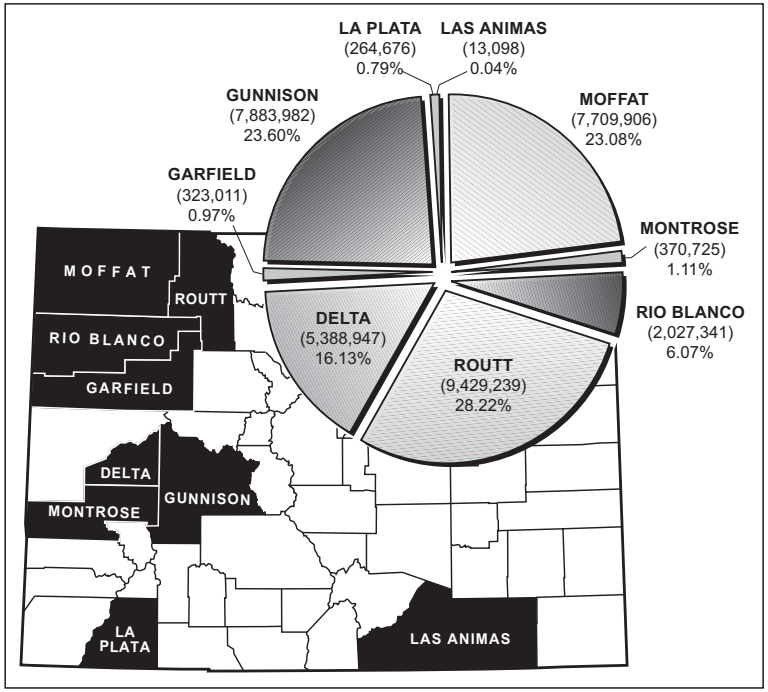


Figure 24. Colorado coal production by county, 2001.

Distribution and Consumption

Coal products are distributed via rail and truck in Colorado. Most of the coal mines in the state supply steam coal via rail to customers in the Front Range and eastern states. About 87 percent of the coal mined in Colorado is used for electricity generation, 11 percent for industrial plants, and 2 percent for coking, residential, and commercial use. The coal mines using truck transportation are mostly mine-mouth to power plant operations such as Trapper, Seneca II-W and Yoast, New Horizon, and McClane Canyon mines. Only the King Coal Mine in La Plata County transports coal by truck to out-of-state customers for use in cement manufacturing. Of the coal mines that use rail transportation, only the Deserado Mine in Rio Blanco County supplies mine-mouth coal to the Bonanza Power Plant 34 miles to the west in Utah.

Less than half of the coal produced in Colorado is burned at Colorado power plants. Most coal is shipped to mid-western states and burned at their power plants as compliance coal to help lower total sulfur content. According to the Department of Energy's Energy Information Administration (EIA) the leading Colorado coal exports were to Kentucky, Texas, Illinois, and Utah (Table 14). Texas used 889,000 tons for industrial plants, Illinois used 442,000 tons for industrial plants, and Utah used 319,000 tons for coking coal. About 1.1 million tons of coal were shipped to Japan from the Somerset Coal Field.

Colorado's relative share of the in-state market is declining. Less expensive Wyoming coal is sold in Colorado, while coal produced in Colorado is shipped out-of-state to supply clean, low-sulfur coal to eastern power plants that need compliance coal. The utilities stockpiled coal in response to higher natural gas prices in 2000. This also increased sales of spot market coal. When gas prices plummeted in 2001, the future became uncertain as to how the demand for coal will change. A mild 2001–2002 winter also curbed demand.

Figure 25 depicts a flow diagram of coal distribution and consumption in Colorado. It shows that 19.3 million tons of coal were consumed in-state (EIA 2000 data). This was a 6 percent increase over the previous year. More than 18.8 million tons of this total were burned at power plants. The Craig power plant was the largest individual consumer of Colorado coal in the state at 4.77 million tons (Table 15). Xcel Energy (formerly Public Service Company of Colorado), 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.

Table 14. Distribution of Colorado coal, 000 short tons (data from 2000 EIA *Coal Industry Annual*).

STATE OF DESTINATION	ELECTRIC UTILITIES Steam, Coal	COKE PLANTS	INDUSTRIAL PLANTS	RESIDENTIAL/ COMMERCIAL	TOTAL
Alaska	15	0	0	0	15
Arizona	926	0	150	0	1,076
Arkansas	0	0	121	0	121
California	117	0	19	0	136
Colorado (In-state)	**12,348**	**0**	**1,040**	**74**	**13,462**
Illinois	1,505	0	442	0	1,947
Indiana	35	0	0	0	35
Iowa	393	0	0	0	393
Kansas	708	0	11	0	719
Kentucky	2,464	0	0	0	2,464
Mississippi	544	0	10	0	554
Missouri	1,363	0	216	0	1,579
Nebraska	6	0	120	0	126
New Mexico	23	0	76	0	99
Oklahoma	0	0	70	0	70
Tennessee	1,121	0	0	0	1,121
Texas	1,450	0	889	0	2,339
Utah	1,531	319	0	0	1,850
Wisconsin	12	0	0	0	12
Wyoming	0	0	147	0	147
Unknown	66	0	0	0	66
TOTAL DOMESTIC	**24,627**	**319**	**3,311**	**74**	**28,331**
Japan	1,099	0	0	0	1,099
TOTAL DOMESTIC/ FOREIGN EXPORT	**25,726**	**319**	**3,311**	**74**	**29,430**

On the consumption side, Colorado electric utilities also burn coal from other states. Wyoming ships much its low-sulfur subbituminous coal through Colorado via railroad lines along the Front Range. Some 50 million tons of Wyoming Powder River coal are sold to Texas facilities. Approximately 9.2 million tons of Wyoming coal were burned at Colorado power plants along the Front Range (EIA 2000 data). This accounts for most of Colorado's coal imports. The other imports were bituminous coal from Pennsylvania (17,000 tons) and Utah (3,000 tons).

On the national level, coal imports increased substantially in 2001. The U.S. imported some 19 million tons of coal. This is 50 percent higher than in 2000. The reason for this is the sustained high prices for U.S. coal since the California energy scare. According to EIA, limited available coal resources also affected the U.S. coal marketplace in 2001. Eastern and southern utilities seeking alternatives to higher priced Appalachian coal were responsible for the foreign buying. The demand for foreign metallurgical coal was also up. Colombia and Venezuela benefited the most as U.S. imports from these countries were up 42 percent. Gulf Coast coal-fired power plants currently purchase these South American coals cheaper than they can buy U.S. coal.

Employment and Productivity

As of December 2001, there were 1,799 coal miners working at five surface and seven underground mines in Colorado

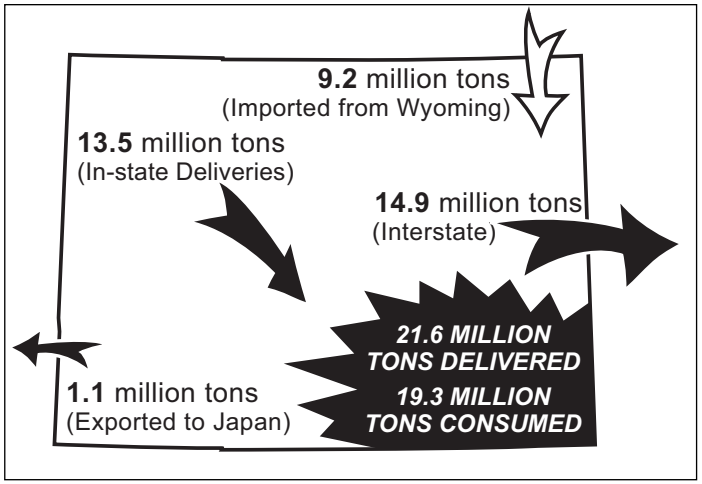


Figure 25. Diagram of the distribution and consumption of coal in Colorado (data from 2000 EIA *Coal Industry Annual*).

(Figure 27). Gunnison County has the most miners employed with 489. Approximately 41 percent of the coal miners in the state are union workers. In 2000, 44 percent of the coal mined in the state was provided by union labor. In terms of worker productivity Colorado's miners produced 7.64 tons of coal per miner-hour in 2000 (EIA 2000 data), a slight decrease over 1999. The EIA, also, reports that union underground miners in Colorado produced coal at a record rate of 9.12 tons per miner-hour. In terms of underground mining, Colorado has the second highest productivity in the nation at 7.84 short tons of coal produced per miner hour. One mine in Wyoming reported 11.61 tons per miner-hour, but that mine closed in 2001. Colorado surface mining productivity was 7.26 tons per miner-hour, much less than Wyoming's reported 38.6 tons per miner-hour.

Productive capacity is the maximum amount of coal that can be produced annually. Colorado has 41.5 million short tons of coal of productive capacity (EIA 2000 data). Between 1996 and 2000, Colorado had the highest average annual percentage increase (9.1 percent) in productive capacity of any state in the nation. EIA defines capacity utilization as the ratio of total production to annual productive capacity. In terms of capacity utilization, Colorado produced 70 percent of its potential in 2000 (EIA 2000 data). This under-utilization is mostly within the underground mining sector. Colorado's underground mines produce up to 64 percent of their capacity. The surface mines utilize 94 percent of their capacity.

The Longwall Census 2002 from *CoalAge* magazine reports five active longwall machines in Colorado (Table 16). These are at Arch Coal's West Elk Mine, Blue Mountain Energy's Deserado Mine, Bowie Resources' Bowie No. 2 Mine, Oxbow Mining's Sanborn Creek Mine, and RAG American's Foidel Creek Mine (Figure 26). Colorado longwalls are still much larger than the average longwall face. As such, three of these mines set both monthly and annual coal production records in 2001.

Table 15. Consumption of coal at electric generation plants in Colorado, 2001 (see Figure 23 for plant locations).

MAP/PLANT	UTILITY	LOCATION	2001 COAL COMSUMPTION	ORIGINATION OF COAL
1 Drake	Colorado Springs Utilities	Colorado Springs	923,646	Colowyo Mine
2 Nixon	Colorado Springs Utilities	Fountain	970,416	85% Wyoming, 15% Colorado
3 Arapahoe	Xcel Energy	Denver	858,125	Wyoming
4 Cameo	Xcel Energy	Palisade	328,305	McClane Canyon Mine
5 Cherokee	Xcel Energy	Denver	2,197,738	Foidel Crk. Mine, Colowyo Mine
6 Comanche	Xcel Energy	Pueblo	2,712,474	Wyoming
7 Hayden	Xcel Energy	Hayden	982,115	Seneca Mines
8 Pawnee	Xcel Energy	Brush	2,510,607	Wyoming
9 Valmont	Xcel Energy	Boulder	626,602	Foidel Crk. Mine, Colowyo Mine
10 Rawhide	Platte River Power Authority	Wellington	1,286,000*	Wyoming
11 Craig	Tri-State G & T Association	Craig	4,769,669	Trapper Mine, Colowyo Mine
12 Nucla	Tri-State G & T Association	Nucla	364,308	New Horizon Mine
13 Clark	Utilicorp	Canon City	132,811	Foidel Crk. Mine, Colowyo Mine
STATE TOTAL			18,662,816	

See Figure 23 for plant locations **Rawhide value is estimated*

Figure 26. Twentymile Coal Company's Foidel Creek Mine longwall operation cutting 10 foot thick Wadge coal bed (photo courtesy of RAG American).

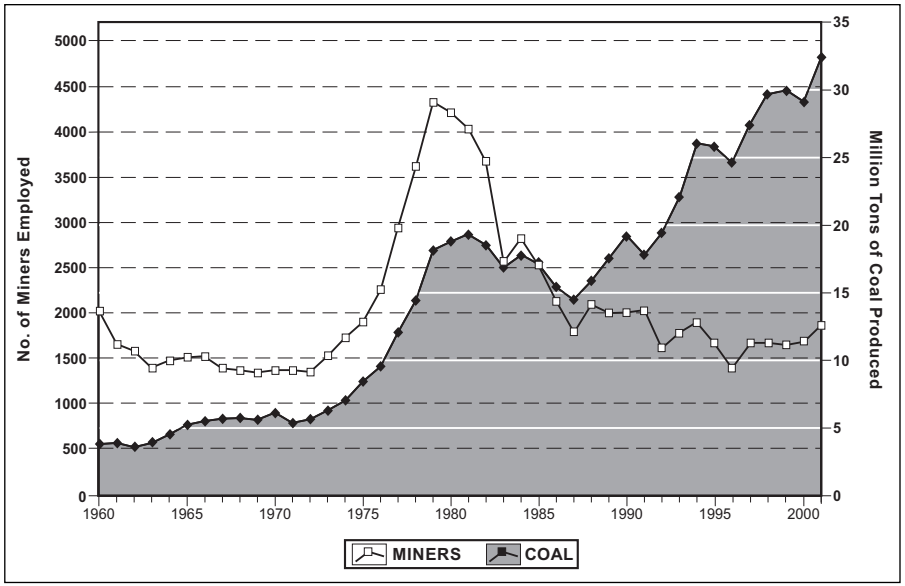


Figure 27. Coal production and miners employed in Colorado, 1960–2001 (data from Colorado Division of Minerals and Geology).

Table 16. Colorado underground longwall mining statistics, 2001 (data from *Coal Age*, February 2002).

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

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 coal with an average 9,800 Btu heat value, 0.38 percent sulfur, and 6.75 percent ash (EIA 2000 data). This is a decrease in heat value over the last ten years due in part to increased imports of Wyoming coal. The average quality of coal received at manufacturing and coke plants in Colorado for 2000 was 10,853 Btu, 0.71 percent sulfur, and 8.33 percent ash (EIA 2000 data). This was the first time that the average heat value of manufacturing coal was less than 11,000 Btu.

Most of Colorado's coal reserves are bituminous. In fact, 75 percent of Colorado coal produced in 2001 was bituminous.

Colorado is second only to Illinois in bituminous coal reserves, but is by far the leader in bituminous compliance coal reserves. The national trend is for power plants to increase their demand for low-sulfur coal. EIA estimates that the U.S. will consume 400 million more 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 2000, the EIA reported that Colorado had 584 million tons of recoverable coal reserves under lease; 388 million tons underground and 197 million tons of surface mineable coal reserves. In terms of mining recovery, the average percentage of coal recovered at Colorado coal mines is 74.28 percent (EIA 2000 data). For underground mines, the average recovery percentage was 66 percent; for surface mines it was 89.28 percent.

The EIA's Demonstrated Reserve Base (DRB) data show Colorado with 16.6 billion tons of coal; 11.8 billion tons underground mineable and 4.8 billion tons surface mineable. In terms of sulfur content, approximately one third of this reserve is less than 0.40 pounds of sulfur per million Btu; 90 percent of Colorado coal reserves are less than 0.83 pounds of sulfur per million Btu. Figure 28 shows coal quality from all major Colorado coal fields. In terms of compliance coal, the future trend is to mine significantly more coal in both northwest Colorado and the Somerset Coal Field.

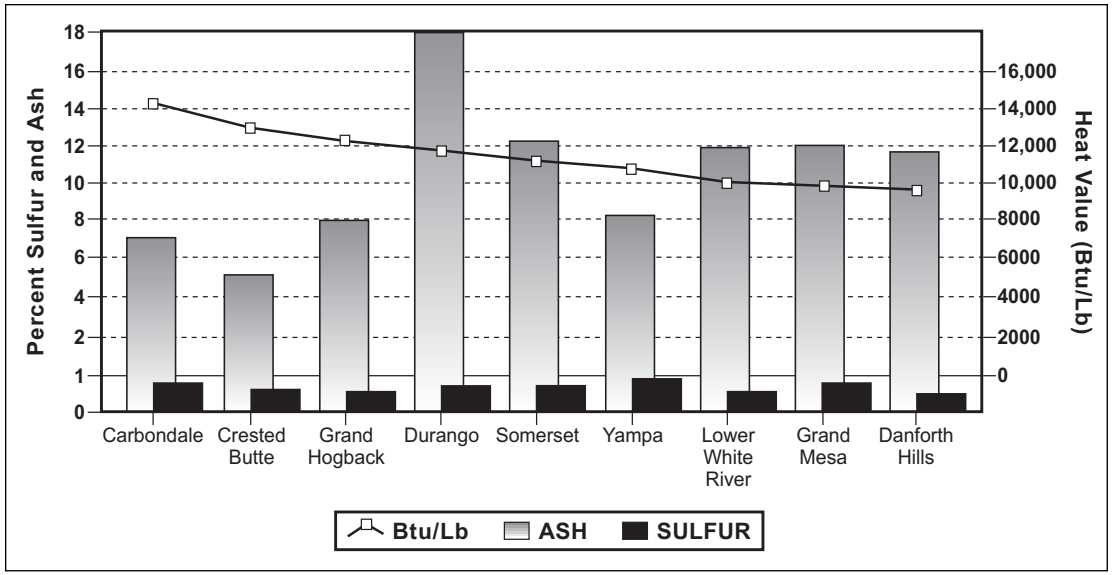


Figure 28.Coal quality analyses of Colorado coal fields (data from USGS *Colorado Plateau Coal Assessment*, Professional Paper 1625-B, 2000).

Colorado Coal News 2001

ADA Environmental Solutions, a Colorado company, has completed a pilot project to measure and remediate mercury emissions from coal-fired power plants. They can reduce mercury emissions by up to 50 percent using injected activation carbon into flue gasses produced by the plant. The research proved that elemental mercury (the form found in Western U.S. coals) could be removed by activated carbon injection in conjunction with an electrostatic precipitator. Xcel Energy reports that their existing Colorado power plants are bag-house types with a 91 percent mercury removal rate.

In 2001, Enron, the largest U.S. energy trading company, filed for bankruptcy. This affected coal marketing as many coal sales are now traded over the Internet. Companies must have assets, not just faith and marketability, to remain in the coal-trading arena. Enron traded in futures. The company survived only while the stock market kept rising. Although Enron was the largest coal trader in the U.S., smaller, more stable companies have taken over their trading. Unfortunately, some coal companies have experienced large monetary losses in the Enron demise.

Northwest Colorado Coal Mining News

Foidel Creek Mine reported coal sales as stable for 2001 when compared to the previous year. As with many mines they

have a large inventory stockpile due to a mild winter in 2001–2002 (Figure 29). The company continues to develop the northern mine section. Recently they drilled an 11-inch diameter pilot bore 1,400-foot deep into the development part of the mine. They are using a raised bore shaft to widen the hole to 20-foot diameter. The hole will be used as a ventilation shaft.

The Seneca Strip Mines near Hayden (Yoast and Seneca II-W) set an all-time monthly production record. They produced 181,912 tons of coal in August 2001. More coal was shipped to the Hayden Power Plant than ever before (Figure 30) as the mine produced 1.7 million tons of coal. Seneca has reserves for about nine more years and would like to extend their surface mining operation as long as possible. Long-term plans are to continue servicing the Hayden Power Plant from an underground reserve southwest of Hayden when the surface tracts are depleted.

At the Colorado Mining Association's 104th National Western Mining Conference in November 2001, northwest Colorado mines won several awards. Colowyo Coal was the large surface mine award winner for reclamation. Seneca Coal Co. and Trapper Mine Co. shared a joint award for an extensive shrub establishment study for re-vegetation study. Twentymile Mine won the reclamation award for the large underground mines for their recent work on subsidence. Twentymile Coal Company's Mine No. 1 and Eckman Park Mine also won a national award from the Office of Surface Mining for innovative reclamation techniques that created a diverse area of post-mining grazing land.

The McClane Canyon Mine in Garfield County reports that coal production at their facility is better than anticipated. Since re-starting in February 2000 they have produced an average 11,100 Btu (as received), low sulfur (0.48 percent), and low ash (11.48 percent) compliance coal. Last year they transferred some equip-

Figure 29. Twentymile Coal Company's Foidel Creek Mine surface facility (photo courtesy of RAG American).

Figure 30. One of Seneca Coal Company's trucks hauling coal from the Yoast mine to the Hayden Power Plant (photo by Chris Carroll).

ment from their mine in Helper, Utah to increase production. They are currently under-utilized in capacity and are looking for out-of-state contracts to increase production. McClane Canyon produces from the upper Cameo seam with no methane gas or faulting problems.

Somerset Coal Field News

The news in 2001 from the North Fork Valley in the Somerset Coal Field was about methane gas. Two mines, West Elk and Sanborn Creek, were both mining deep, with overburden depths greater than 2,000 feet for most of the year. Production at both mines was slowed because of excessive methane gas. New ventilation drillholes helped reduce the hazard at Sanborn Creek Mine. Currently they are developing a continuous miner network into the new Elk Creek Tract. This will be the Elk Creek Mine, located north of Sanborn Creek.

West Elk Mine reported methane gas in their panel 14. Methane levels more than five times greater than normal were detected on the longwall face. This was due to the tight pressure conditions encountered while mining more than 2,000 feet deep. They drilled 19 methane drainage holes to the surface and horizontally in the sandstone above the coal to help with ventilation along the active mining face. Methane drainage allowed mining to resume and West Elk still produced over five million tons of coal for 2001 (Figure 31). Drilling in the rugged mountains above the coal mine takes much permitting and planning, as the land is adjacent to U.S. Forest Service (USFS) lands. Issues related to the USFS Roadless Area Conservation Rule are not finalized as yet. The measure, which limits road building and economic development on certain USFS lands, will be re-examined by the USFS this year.

Bowie No. 2 Mine has maximized coal production from its mine in 2001. In addition to setting their new annual coal production record, in August they set their all-time monthly production record with 532,302 tons of coal produced. They are operating in their new lease area, Iron Point.

Other Colorado Coal Mining Region News

Deserado Mine near Rangely and the King Coal Mine near Durango both set new monthly coal production records. In March 2001, Deserado Mine produced 262,002 tons of coal. In December King

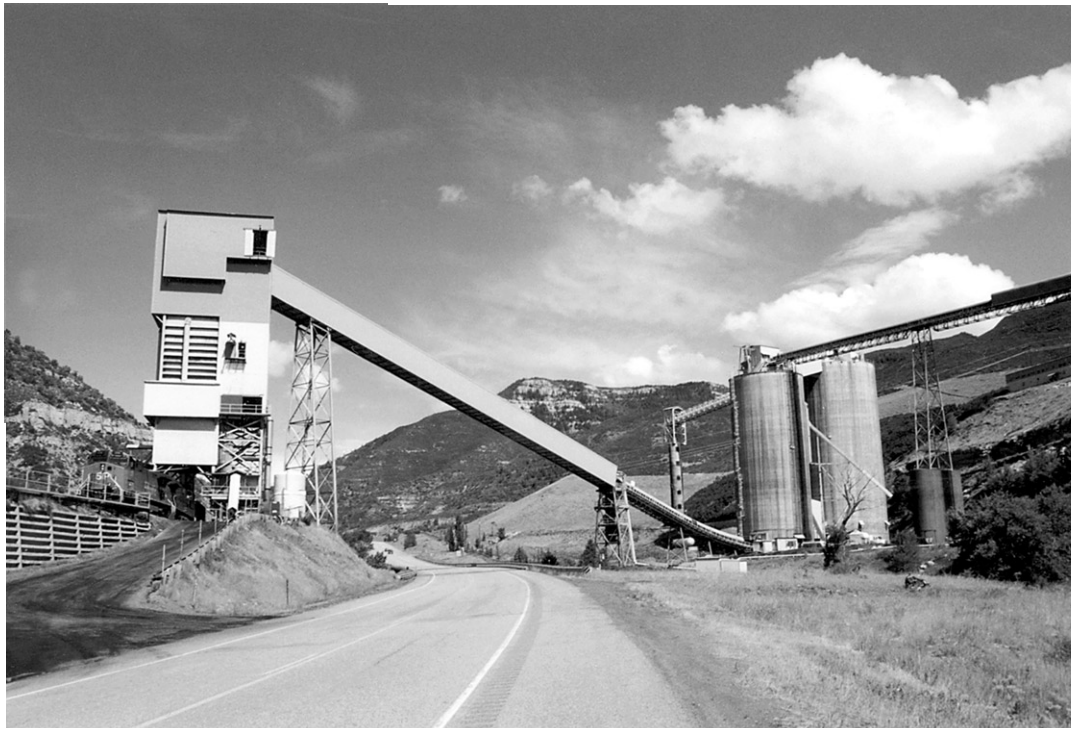


Figure 31. Loadout facility at West Elk Coal Mine, Gunnison County, Colorado (photo by Chris Carroll).

Coal Mine reported 32,160 tons of coal produced. King Coal will soon get a new 1,300-acre federal lease, which will allow for an additional 15 years production.

The Lorencito Coal Co. opened a new coal mine in November 2001, the first new coal mine to open in Colorado in years. The Lorencito Canyon Mine (Figure 32) produced the first coal since 1995 from the historic Raton Mesa Coal Field near Trinidad.They use a combination of surface techniques to mine thin (18 inch to four foot) coal seams from the Raton Formation. The "N_A" seam is the highest heat value coal now produced in Colorado (greater than 13,000 Btu). Lorencito plans to market this high quality coal to power plants in Tennessee and Kentucky. Bruce Addington of Lorencito Coal Co. estimates that the reserve includes 15 million tons of surface coal and 85 million tons of underground coal in their 17,000 acre lease. They plan to ship some 40,000 tons of coal a year from the Lorencito Canyon Mine to the Tennessee Valley Authority.

In summary, the coal industry in Colorado was healthy and economically viable in 2001. All economic variables are good: the price of coal was stable, and coal production and employment were up. This trend is forecast to continue, although slightly lower, through the immediate future well into 2002.

Figure 32. Outcropping of Raton Formation coal beds, Lorencito Canyon Mine, Las Animas County, Colorado (photo by Chris Carroll).

NON-FUEL MINERALS AND URANIUM

By John Keller

INTRODUCTION

Non-fuel mineral production in Colorado includes metals (other than uranium), industrial minerals, and construction materials. For 2001, a preliminary estimate by the U.S. Geological Survey of the total value of non-fuel mineral production in Colorado is $576 million. This is a 3.3 percent decrease in value over the 2000 production value of $596 million. Most of the decrease in value is due to decreased sand, gravel, and crushed stone production. In 2000, Colorado ranked 25th among the 50 states in total non-fuel mineral production value. Figure 33 shows the value of non-fuel mineral production in Colorado, and the percent of the total value of each commodity type.

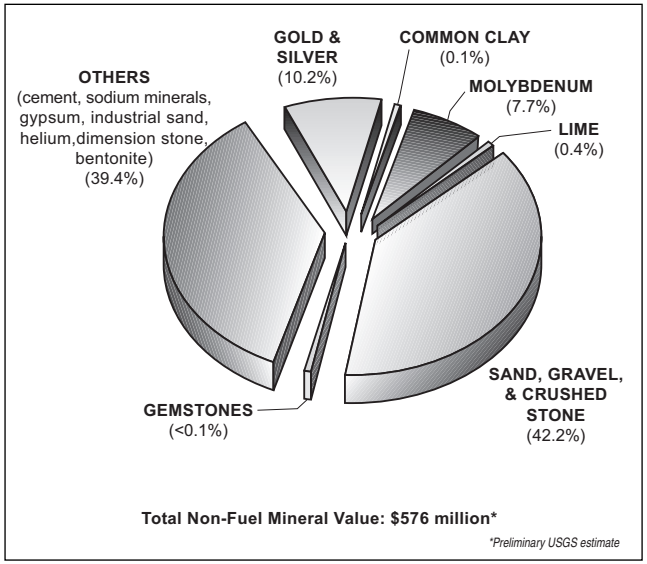


Figure 33. Colorado non-fuel mineral production value, 2001.

Figure 34 is a map of the major active industrial mineral and metal mines in the state, and the major exploration and development projects. Table 17 lists the mines and prospects, their owners, mine type, and commodity.

METALS

Gold and Silver

Cresson Mine, Teller County

The Cripple Creek and Victor Gold Mining Co. (CC&V) continues to operate the only major precious metals mine in Colorado. The Cresson Mine (Figure 35), near the towns of Victor and Cripple Creek in Teller County, produced 214,010 ounces of gold in 2001, down 11.6 percent from the 242,000 ounces produced in 2000 (Figure 36). The decrease in metal production is attributable to a lower average ore grade. Tons of ore mined actually increased to 11.5 million tons in 2001 from 11.3 million in 2000. 2001 silver production at the mine was 91,000 ounces. Based on the average prices for the metals over the entire year, the value of the gold produced is estimated to be $58.4 million,

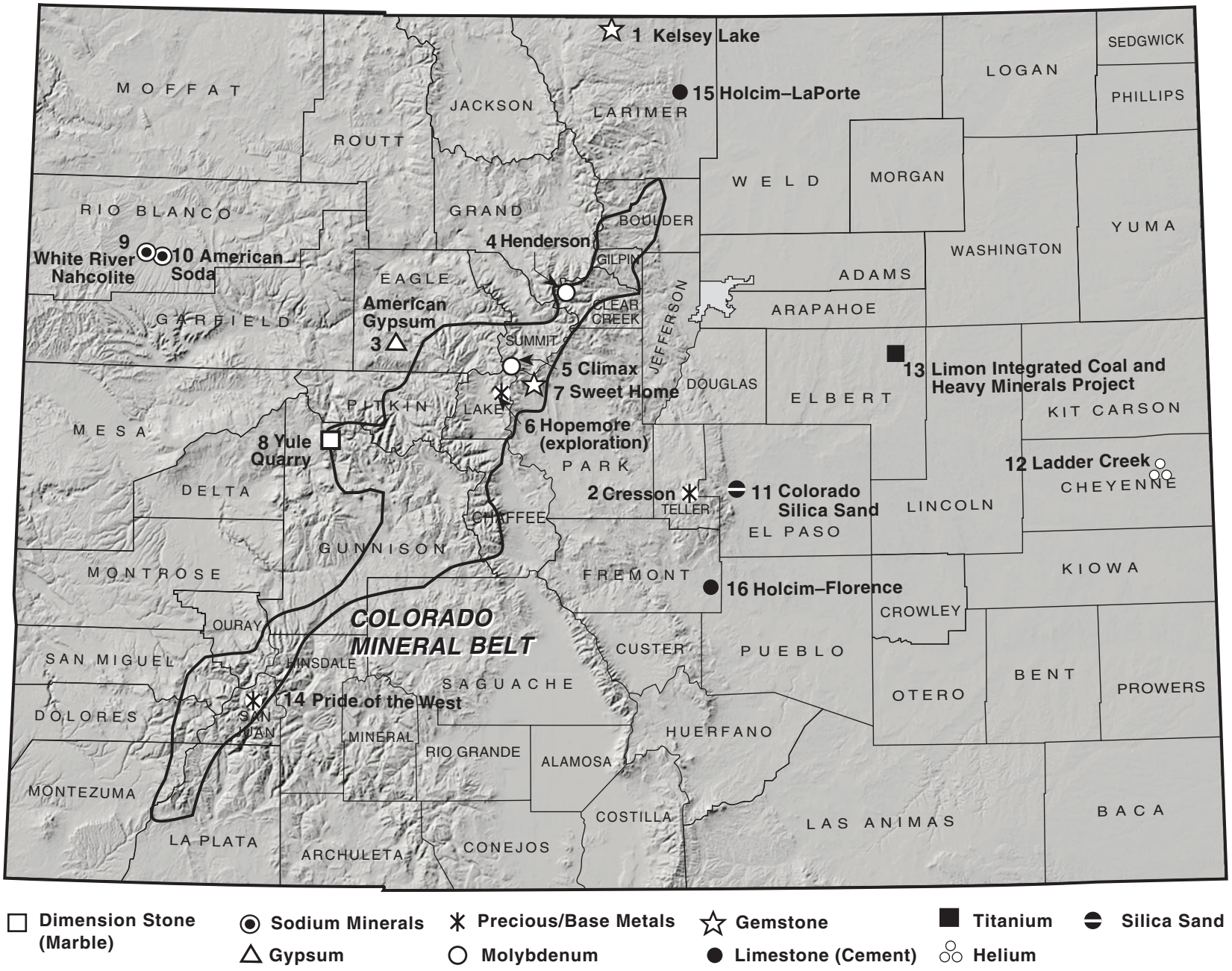


Figure 34. Map of major metal and industrial minerals mines and prospects (excludes sand, gravel, and crushed stone operations).

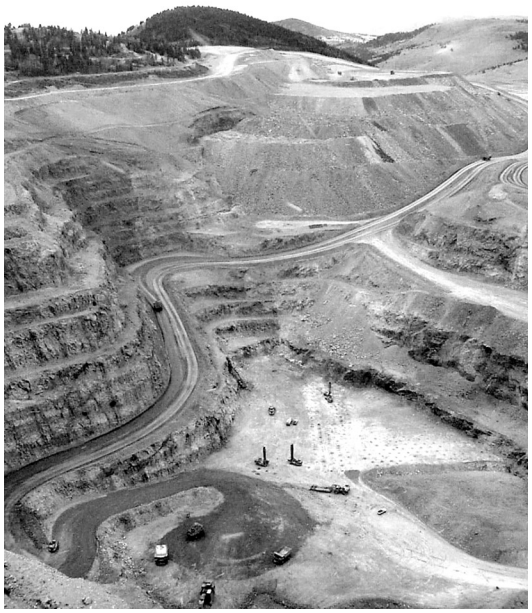


Figure 35. View of the Cresson Mine near Cripple Creek. Note the drill rigs preparing the next blast.

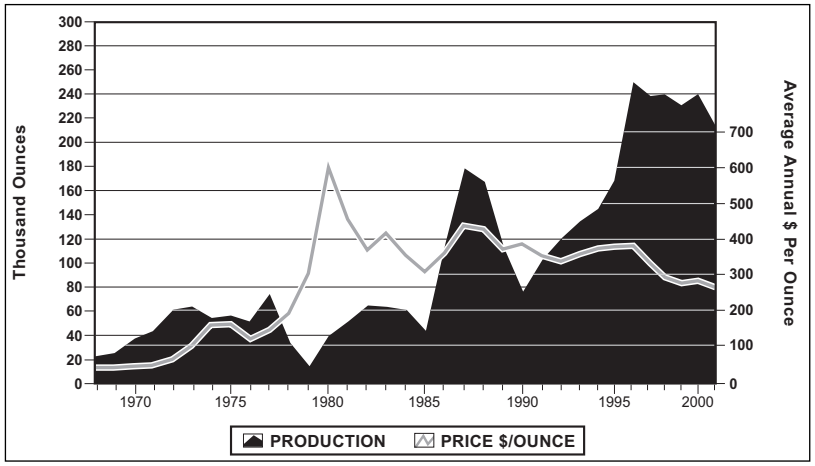


Figure 36. Colorado gold production and average gold prices, 1968–2001.

Table 17. Selected non-fuel mineral producers and prospects in Colorado. Numbers refer to map in Figure 34 (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	Cresson	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	Climax	molybdenum	UG,OP	Phelps Dodge Corp.
6	Hopemore	gold, silver	EX	Leadville Mining and Milling Corp.
7	Sweet Home	rhodochrosite (specimen)	UG	Sweet Home Rhodo, Inc.
8	Yule Quarry	marble	UG	Sierra Minerals Corp.
9	White River	sodium bicarbonate	SOL	White River Nahcolite Minerals
10	American Soda	soda ash and sodium bicarbonate	SOL	American Soda, LLC
11	Colorado Silica Sand	silica sand	OP	Oglebay Norton Industrial Sands
12	Ladder Creek Plant	helium	P	Duke Energy Field Services
13	Limon Integrated Coal and Heavy Minerals Project	titanium, zircon, garnet, coal	EX	Radar Acquisitions Corp.
14	Pride of the West Mill	gold, silver, base metals	P	Silver Wing Co., Inc.
15	La Porte	limestone/cement	OP/P	Holcim, Inc.
16	Portland	limestone/cement	OP/P	Holcim, Inc.

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

and the value of silver is estimated at about $400,000. The mine currently employs approximately 300 people and is the largest private employer in Teller County. CC&V is a joint venture between AngloGold and Golden Cycle Gold Corp.

Gold prices remained low in 2001, averaging about $273 per ounce, a $6 per ounce decrease from 2000 (Figure 36). Silver averaged $4.35 per ounce, compared to $4.95 per ounce in 2000. Despite the low prices, CC&V continued to be optimistic about the future of the mine. The company is planning a major expansion at the mine beginning in 2003. By 2006, gold production is expected to increase to 500,000 ounces per year from 20 million

tons of ore mined. The company has received necessary permits from state and county regulatory agencies for the expansion project. The current reserve base is sufficient to support gold production until 2012 at the expanded production rate. In April of 2001, CC&V purchased and put into use the largest haul truck ever to operate in Colorado. Costing $2.3 million, the Euclid-Hitachi EH 4500 is capable of hauling 310 tons of ore per load. Several more of these trucks are scheduled to be purchased over the next three years.

Also in 2001, CC&V completed the highest bridge in the state highway system as part of its project to realign traffic on State Highway 67. The bridge spans 1,218 feet and cost CC&V $18 million. The highway realignment was done to end conflicts between mine traffic and other traffic.

Figure 37. Pride of the West Mill near Silverton, Colorado (photo courtesy of Steve Fearn).

Gold was originally discovered in the Cripple Creek district in 1891. Since then, the district has produced about 22 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 (formerly called the Howardsville Mill) 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., which also owns the nearby Silver Wing and Gold King mines. The mill (Figure 37) will also eventually process new ore from those mines and possibly other local small mines. 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 scavenges gold from ore in enclosed agitation tanks at the end of the milling process. The cyanide in solution is then destroyed by hydrogen peroxide. The company is in the process of constructing a liner for the tailings pond. The mill is expected to start up later in 2002. A 15,000 ton stockpile of ore from mine waste piles is already at the site awaiting processing, delivered by the Animas River Stakeholder's Group.

The 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, a local San Juan County group. The project is appreciated by local business and economic development groups because it will diversify the area's economy, employing as many as 50 people when full production is achieved.

Hopemore Mine, Lake County

The Leadville Mining and Milling Co. is continuing to evaluate deposits of gold and other metals at its properties near Leadville, Colorado. The Hopemore Mine and mill facility are the most significant

of its properties in the area. However, in 2001, the company focused most of its attention on other metal exploration projects outside of the United States. The Hopemore Mine is now dormant. No major exploration or development work was reported by the company on its Leadville region holdings in 2001.

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. Although Newmont does not have any operating mines at this time 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. However, the mine cut its production of the metal in 2001, as it did in 2000, because of low metal prices. The underground mine is owned by Climax Molybdenum Company, a subsidiary of Phelps Dodge Corp. In 2001, the mine and mill produced 5.6 million tons of ore containing 18.8 million pounds of molybdenum oxide, down 6.0 percent from the 20 million pounds produced in 2000 (Figure 38). According to the U.S. Geological Survey Mineral Information program, the 2001 average price for contained molybdenum was $2.36 per pound, down from the $2.68 estimated in 2000. The estimated total value of molybdenum produced at Henderson in 2001 is $44.4 million. The operation continues to employ about 320 workers at the mine and mill. Current efforts at the Henderson Mine are focusing on development mining which is intended to eventually increase overall molybdenum production in 2003.

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.

Climax Mine, Lake County

In 2001, Climax Molybdenum Company received a national award from the U.S. Environmental Protection Agency for its successful use of sewage waste (bio-solids) to augment capping material and create topsoil as part of the effort to rehabilitate the large tailings impoundment at Climax. The Climax Mine between Leadville and Copper Mountain continues to be managed on a "care and maintenance" basis. However, a large amount of molybdenum

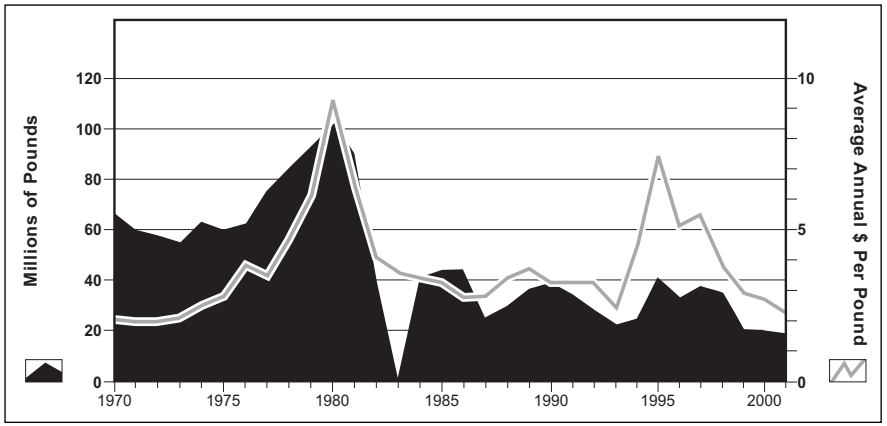


Figure 38. Molybdenum production in Colorado and average molybdenum prices, 1970–2001.

ore remains unmined at the site. Should demand for molybdenum increase significantly in the future, the Climax Mine could be placed into operation again.

Mt. Emmons Deposit, Gunnison County

The large molybdenum deposit at Mt. Emmons near Crested Butte was discovered by AMAX geologists in the mid-1970s. Now owned by the Mt. Emmons Mining Company (a Phelps Dodge subsidiary), the deposit remains an unmined resource. The price of molybdenum has been too low in recent years to justify developing the deposit into a mine. If and when a decision is made to attempt to develop a mine, it will be controversial. Environmental groups oppose development of the world-class metal deposit into an operating mine. According to the *Crested Butte Chronicle & Pilot*, in August 2001, the Mt. Emmons Mining Co. sought to patent its federal mining claims on the property. Apparently, no decision has yet been made regarding the patent application. *The Denver Post* reported in January 2002 that the Colorado Supreme Court overturned a water-court ruling that had previously denied the company's application for a conditional water right in the Gunnison River Basin. The mine and processing plant, if built, would require about 1,500 acre-feet of water per year to operate.

Base Metals

Base metals ceased being produced in the state of Colorado in 1999 when the Black Cloud Mine near Leadville ran out of ore and shut down. Underground salvage and reclamation work began in 1999. In July 2001, ASARCO, Inc. announced it was reducing the remaining workforce at the mine from twelve to three. The remaining staff will perform only "care and maintenance" functions. The Black Cloud Mine was the last operating mine in the 140 year history of the Leadville district. It produced lead, zinc, silver, copper, and gold. ASARCO Inc., the owner of the mine, is a wholly-owned subsidiary of Grupo Mexico.

Uranium

In January of 2001, the price for uranium oxide began to rise from its low point of $7.10 per pound. By the end of the year, the price for the metal reached $9.60 per pound, and was still rising. Figure 39 shows the average uranium price from 1987 to 2001. Colorado uranium mine production came to an end in March 2000 when the Schwartzwalder Mine in Jefferson County shut down. Since the mine began its most recent round of production in 1995, it has produced a total of 1.2 million pounds of uranium oxide (U_3O_8). 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. As of this writing, the state permit is in the bonding process. The quarry is expected to produce 100,000 tons of aggregate per year, utilizing a four-person mining crew.

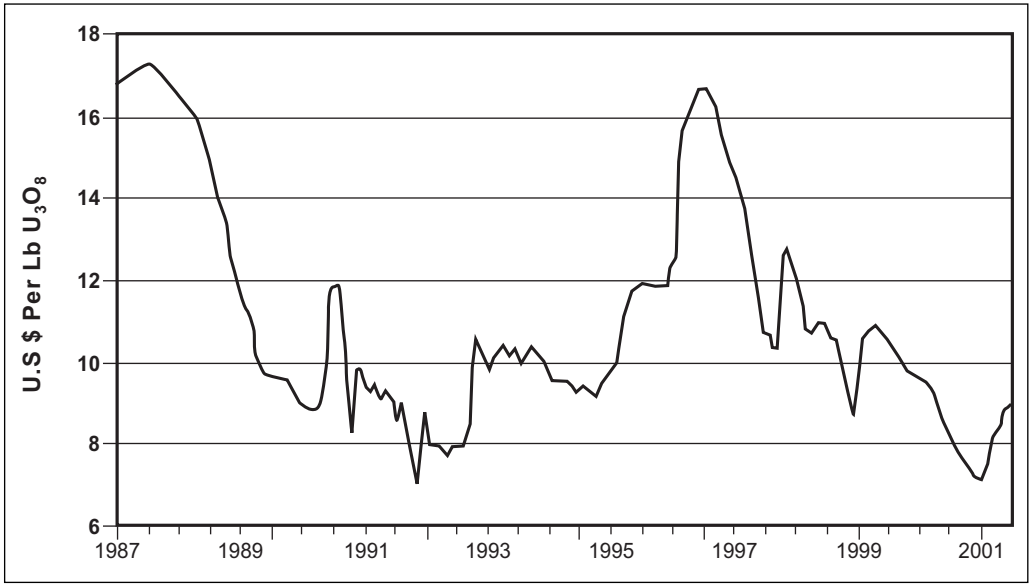


Figure 39. Generalized spot prices for uranium, 1987–2001.

The owner of the Schwartzwalder Mine, Cotter Corporation, is a subsidiary of General Atomics of San Diego. Cotter Corp. owns and operates the newly refurbished zirconium-uranium processing mill in Canon City, Colorado. In 2001, the company, together with partner CMS Enterprises Development, LLC of Dearborn, Michigan, converted the old uranium mill to process zirconium ore. Uranium will still be produced, but as a byproduct of zirconium and silicon processing. The zirconium ore comes from a government stockpile in Indiana. In the future, ore may come from a mine in South America. The mill can process 150 tons of the zirconium-uranium ore per day, and employs about 140 people at full production. With the conversion of the plant to process the zirconium ore, it will no longer be capable of processing the types of uranium ore that have traditionally been mined in Colorado.

Uranium Exploration

According to reports in mining industry news publications, Cotter Corp. began exploration drilling in August 2001 in the Monogram Mesa and Slick Rock areas in western Colorado. No further details were available at the time of this writing.

INDUSTRIAL MINERALS & CONSTRUCTION MATERIALS

by John Keller and Beth Widmann

Introduction

The largest segment of the non-fuel mineral industry in the state 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, Gravel, and Crushed Stone

According to the U.S. Geological Survey, more than three billion tons of sand, gravel, and crushed stone were produced in the U.S. in 2001. The main uses for aggregate are road base and coverings, concrete and asphalt, and fill material. Colorado produced nearly 50 million tons of aggregate in 2001 (Figure 40) and ranked seventh in the nation for sand and gravel production. Contrary to the national trend, 77 percent of Colorado's aggregate is sand and gravel (Figure 41). Sand and gravel production is down 10 percent from 48.39 million tons in 2000 to 43.54 million tons in 2001. Similarly, crushed stone production has decreased 17 percent from last year's total. The total value of Colorado aggregate was more than $243 million, but was down 22 percent over the 2000 value of $328 million. The unit value of Colorado sand and gravel was

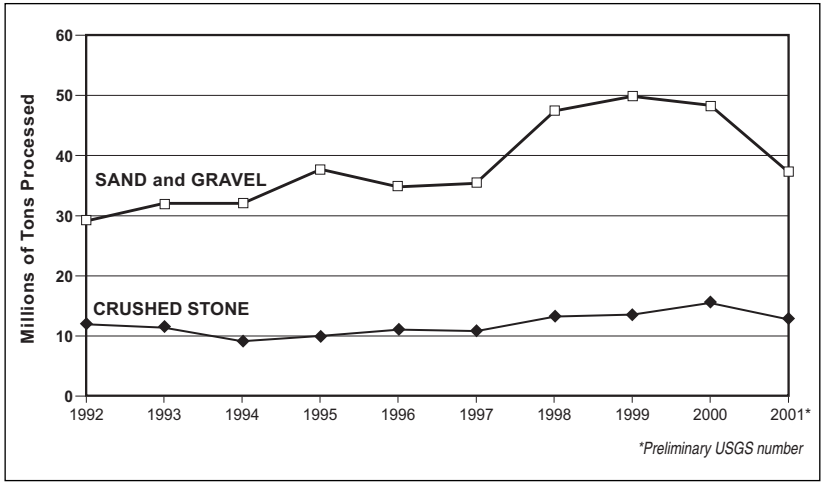


Figure 40. Production of sand and gravel vs. crushed stone in Colorado, 1992–2001.

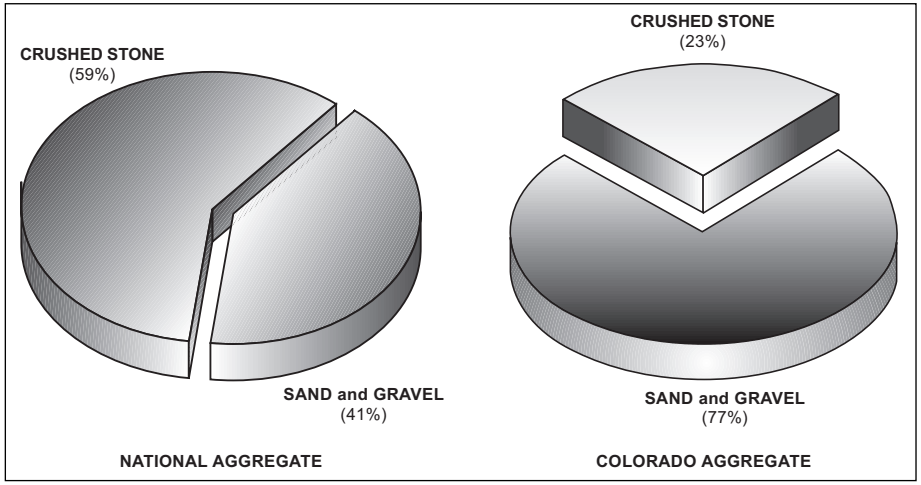


Figure 41. Percentage of sand and gravel v.s crushed stone produced in Colorado and the U.S. in 2001.

Table 18. Leading producers and number of sand, gravel, and crushed stone operations in Colorado.

COMPANY NAME	NUMBER OF OPERATIONS	
	Crushed Stone	Sand & Gravel
Aggregate Industries, Inc. (Camas Colorado)	1	6
Albert Frei & Sons, Inc. (Associated Aggregates)	1	4
Asphalt Paving Company	1	1
Cemex, Inc. (Southdown, Inc.)	1	0
Continental Materials Corp. (Castle Concrete Co.; Transit Mix Concrete Co.)	3	3
L. G. Everist, Inc.	0	3
LaFarge Corp.	2	33
Oldcastle, Inc. (Materials Group)	0	9
Valco, Inc. (Canon City Concrete Division)	0	6

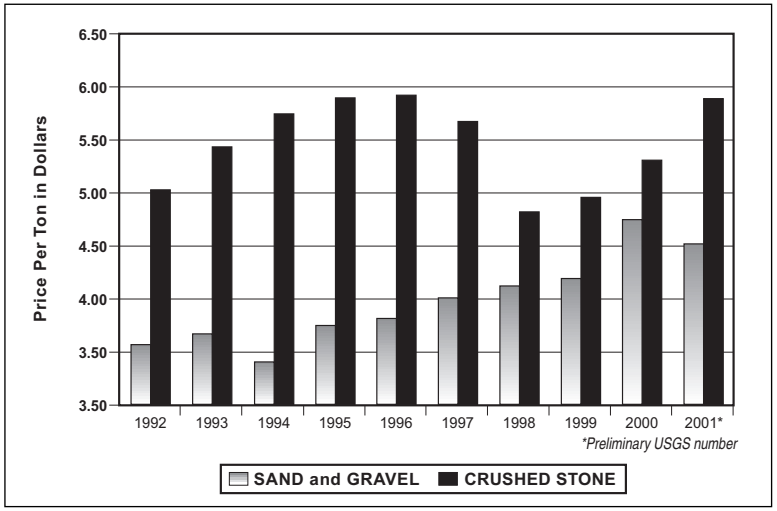


Figure 42. Average estimated price per ton of sand and gravel vs. crushed stone in Colorado, 1992–2001.

$4.52 per ton, which was slightly higher than the national average of $4.45 per ton (Figure 42). Colorado crushed stone had an average value of $5.89 per ton, which was also higher than the national average of $5.04 per ton. Lafarge Corp. is Colorado's leading producer of sand, gravel, and crushed stone. Table 18 lists other significant contributors to Colorado's aggregate production.

Prior to 1975, the national trend in aggregate production was towards more 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 43). There are several reasons for this shift in the national trend. Sand and gravel operations disturb a relatively large area to depths typically less than

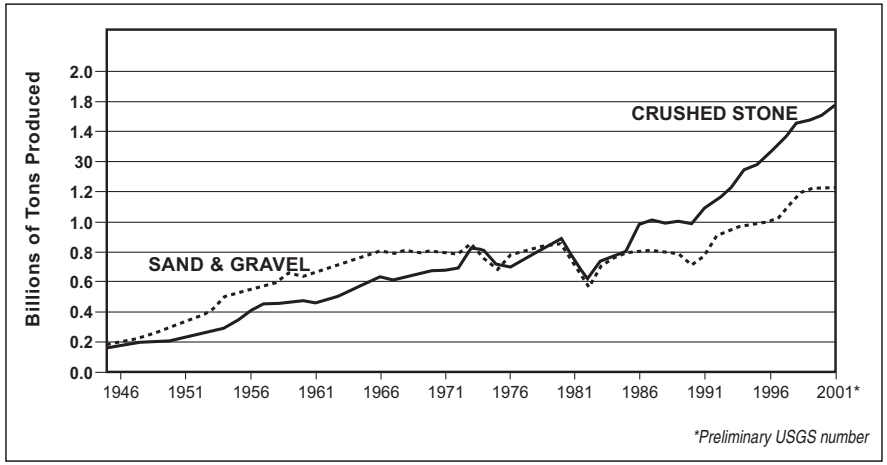


Figure 43. U.S. production of sand and gravel vs. crushed stone, 1945–2001.

100 feet. Although sand and gravel deposits can be easily excavated using cheaper mining processes such as bulldozing and front-end loading, the location of most of the deposits in ecologically sensitive environments adjacent to streams and rivers can raise environmental and political issues, which usually become very costly to address. Furthermore, these areas are often prime agricultural lands and are increasingly viewed as premium sites for residential development. Conversely, hard rock mining produces more aggregate from a smaller disturbed area because the aggregate material extends to a much greater depth. These mines are able to operate vertically, as opposed to sand and gravel operations which mine laterally. An added benefit is that crushed stone quarries can be located in mountainous areas that have less pressure for development. However, crushed stone operations incur the additional cost of drilling and blasting, and the further the quarry is from developed areas, the greater the transportation costs.

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 sedimentary rocks of the Piceance Creek Basin in northwestern Colorado. It is estimated that 32 billion tons of nahcolite are present within the basin.

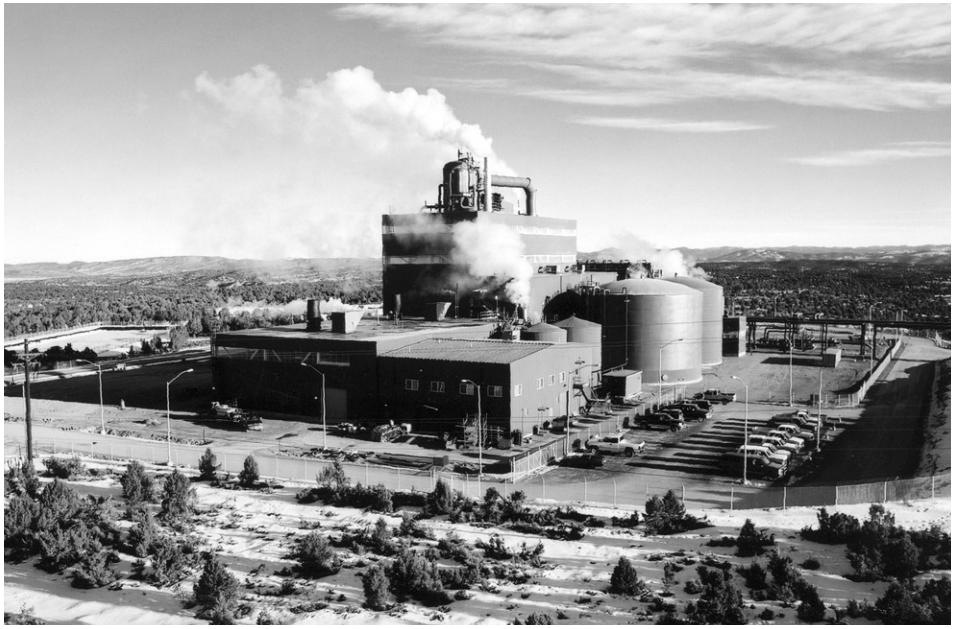


Figure 44. American Soda's plant at the nahcolite solution mine, Rio Blanco County (photo courtesy of American Soda).

American Soda LLP, Rio Blanco County

In October 2000, American Soda, LLP began production of soda ash and sodium bicarbonate in western Colorado. The company built a state-of-the-art solution mine, 44-mile dual pipeline, processing plant, and railroad spur to produce and ship its sodium products. The mine and plant have a nameplate designed production capacity of 800,000 tons per year of soda ash and 150,000 tons per year of sodium bicarbonate. In 2001, the first full production year, the company shipped slightly less than one-half of the nameplate capacity of soda ash and sodium bicarbonate. In 2002, the company plans to ramp up to full capacity.

The solution mine, located in Rio Blanco County within the Piceance Creek Basin, currently consists of 26 production wells that use hot water to dissolve nahcolite (natural sodium bicarbonate) from several stratigraphic horizons in the Eocene-age Green River Formation, about 2,000 feet below the surface. The company controls over 7,000 acres of mineral leases on U. S. Bureau of Land Management (BLM) land. They estimate that the nahcolite in situ resource is 3.5 billion tons, with over one billion tons of recoverable nahcolite.

The dissolved sodium bicarbonate is converted to sodium carbonate (soda ash) at a plant near the well field (Figure 44). Still in a hot solution, the soda ash is pumped through one of the two 44-mile parallel pipelines to the processing plant just north of the town of Parachute in Garfield County. The other pipeline returns clean, recycled water from the processing plant to the mine site, where it is used again to dissolve more nahcolite. In August, 2001, American Soda received approval from Garfield County to expand its processing plant. The expansion will allow the company to extract residual soda ash from mine wastewater.

White River Nahcolite, Rio Blanco County

White River Nahcolite Minerals, LLC, a subsidiary of IMC Chemical, has been producing sodium bicarbonate by solution mining for several years at a site close to American Soda's mine. White River produced 86,496 tons of sodium bicarbonate in 2001. In 2000, the solution mine produced 102,000 tons of the material. The mine's designed capacity is 125,000 tons per year. Both food grade and industrial grade products are produced.

Rock School Lease, Rio Blanco County

AmerAlia, Inc., through its new subsidiary Natural Soda, Inc., controls the Rock School Lease, a nahcolite property in the Piceance Creek Basin. Eventually, the company plans to produce sodium bicarbonate at a rate of 150,000 tons per year. However, in 2001 AmerAlia deferred plans for development of a mine and plant on the property due to a shortage of working capital. Core drilling and resource evaluation work performed in 1996 on the 1,320 acre Rock School Lease determined a nahcolite mining interval height of 510 feet that averaged 26.4 percent nahcolite. The leases, valid through 2011, are located on BLM land.

Gypsum

American Gypsum, Eagle County

Centex Construction Products, Inc.'s American Gypsum operation produced 543,000 tons of gypsum in 2001 from its mine near the town of Gypsum in Eagle County. That figure is a decrease of 6.4 percent over the 2000 production of 580,000 tons. The decrease in production is attributable to a slowing construction economy and competition from new gypsum production in the Midwest. In 2001, the company filed a request with the BLM to relocate its gypsum mine in the future as reserves at the current mine site become depleted. The proposed new mining area is northeast of the current operations. The gypsum is manufactured into wallboard and other products at the plant in the town of Gypsum. Approximately 50 percent of the wallboard produced at the plant goes to the Colorado construction industry and the remainder is marketed throughout the U.S. The mine and plant employ approximately 120 people. The gypsum is present within the Eagle Valley Formation evaporite sequence of Pennsylvanian age.

Smaller gypsum mines in Fremont and Larimer Counties produce gypsum for cement manufacture and for soil conditioners. 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 (US) Inc., Fremont and Larimer Counties

Holcim (US) Inc., formerly Holnam, Inc., operates two portland cement manufacturing plants in the state, one near La Porte in Larimer County and one east of Florence in Fremont County. The La Porte Plant produces about 470,000 tons per year of cement using the dry process. The Portland Plant near Florence 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. The plant became operational in early 2001, but had to shut down in August because of a crack in one of four columns in a preheating tower. Repairs are continuing and the plant is scheduled to resume full production in June 2002. When the new Portland Plant comes online, the La Porte Plant is scheduled to close permanently.

Both the Portland Plant and the La Porte Plant utilize Cretaceous-age limestone of the Niobrara Formation as their basic

raw material. Some sandstone or shale, gypsum, and iron ore is also needed for cement production, but the tonnages of these materials is small compared to limestone. All but the iron ore is mined locally near the cement plants.

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 build the approximately $200 million plant and produce one million tons of cement per year. The company has signed a lease with the Colorado State Land Board to mine limestone from a local deposit for cement manufacture. No start-up date for plant construction has yet been announced.

Figure 45. Truck hauling largest block of marble ever quarried from the Yule Quarry in Gunnison County. The block weighed 58 tons (photo courtesy of Sierra Minerals Corp.)

Clay and Shale

Common clay and shale are mined in several places in Colorado. Common clay is used mainly for brick making and shale is mined to produce lightweight aggregate. Clay is mined primarily in eastern Colorado, especially along the Front Range in Jefferson, Pueblo, and Fremont Counties. In 2001, clay mines in Colorado produced 296,000 tons of common clay valued at about $2 million.

The year 2001 brought an end to a long history of clay mining in the city of Golden. The Parfet family had been in the clay mining business in Golden since 1877, but shut down their operations last year after donating land to the city for a new golf course and recreation campus. The clay pits were notable for an abundance of fossil dinosaur tracks. The "Fossil Trace" golf course plans to preserve the dinosaur tracks which otherwise would have been covered up as part of the final mine closure plan. Common clay was mined from deposits in the Cretaceous-age Laramie Formation in the Golden area. Other similar deposits both north and south of Golden continue to be mined.

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 multi-story buildings. Cinder blocks are commonly made with lightweight aggregate.

Dimension Stone

In 2000, 20,100 tons of dimension stone with an estimated value of $4.1 million was quarried in Colorado. These statewide production values have not been made public for the year 2001.

Yule Quarry, Gunnison County

The Yule Quarry in Gunnison County had an impressive year producing its fine-quality marble. In 2001, the Yule Quarry produced 4,937 tons of marble valued at approximately $1.2 million. The stone is used by the Veterans Administration for national cemeteries, by other monument fabricators, and sculptors. Figure 45 is a photograph of a 58-ton marble block that was cut for renowned sculptor Gerald Balciar, of Parker, Colorado. This massive block surpassed the previous record 55-ton stone produced in 1931 for the Tomb of the Unknowns in Washington, D.C. The owner of the quarry is Sierra Minerals Corp. of Centennial, Colorado. The quarry now 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 Unknown Soldier 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 U.S. 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, 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 2001, 65,000 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.

Titanium

Limon Integrated Coal and Heavy Mineral Project, Elbert County

Radar Acquisitions Corp. of Calgary, Alberta is actively pursuing development of its "Limon Integrated Coal and Heavy Mineral" project on the plains of eastern Colorado near the town of Limon. The project was formerly known as "Riverbend" and "Titanium Ridge". Titanium minerals (ilmenite and rutile), garnet, zircon, and some rare earth minerals are present within paleo beach placer deposits in the Late Cretaceous Fox Hills Sandstone. In addition, deposits of lignite coal overlie the heavy mineral deposits. The coal is also being considered for its economic potential, and Radar Acquisitions is discussing the coal resource potential of the project with various coal and utility companies. Much of the project is on land leased from the Colorado State Land Board.

In April, 2001, Radar Acquisitions Corp. announced revised resource estimates for heavy minerals on the project. The estimate was performed by Watts, Griffis, and McQuat Ltd. Using a 1 percent total-heavy-minerals cutoff grade, a measured and indicated resource of 14.2 million tons of material containing 2.3 percent

ilmenite, 0.1 percent rutile, 0.5 percent zircon, and 2.9 percent garnet was determined for part of the project area. In March 2001, the company reported an estimated total lignite coal resource of 105.1 million tons on land that is under lease from the Colorado State Land Board. The company also performed research on mineral processing technology for the deposit. During 2001, the company made progress with respect to signing a lease agreement with RME Land Corp., a subsidiary of Anadarko Petroleum Corp., for an additional 16,640 acres of mineral rights in the area.

Titanium oxide is primarily used as pigment in paint and plastic. Titanium metal is used as a steel alloy in applications where lightweight and high strength is needed. Zircon is used in ceramics, TV tubes, glass, and enamel. Garnet is used as an abrasive blast cleaning agent, waterjet cutting, and water filtration.

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. "Moss rock" is a term used to describe natural boulders that have a covering of lichen on them. 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.

Figure 46. Mine cut at the Kelsey Lake–2 diamond-bearing kimberlite pipe, Kelsey Lake Mine, Larimer County. Light-gray material is Devonian-age kimberlite, dark-gray country rock is Precambrian granite.

GEM AND SPECIMEN MINERALS

Diamonds

Great Western Diamond Company, Larimer County

The Kelsey Lake Mine, in Larimer County near the Wyoming border, produced diamonds for all of the 4th quarter of 2001, and mining operations are ongoing as of March 2002. A partnership that includes Roberts Construction Co. of Wyoming and BJ&J Ltd. of Boulder, Colorado has an option on the purchase of Great Western Diamond Co., which owns and operates the mine. In 2001, the mine implemented a new crusher system and other upgrades to its processing plant, and began mining on the Kelsey Lake No. 1 kimberlite pipe. Kelsey Lake No. 2 kimberlite (Figure 46) continued to be mined as well. Diamonds from the mine are marketed under the name "Colorado Diamonds". In 1996, a 28.3-carat light-yellow diamond was recovered at the mine, the fifth largest diamond ever found in the U.S. A slightly smaller 28.2-carat stone was also discovered. This stone was cut into a 16.86-carat polished diamond, the largest finished diamond that a North American mine has ever produced.

The Kelsey Lake Mine is an open pit operation on two kimberlite pipes 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 reserve is estimated at 18.7 million tons grading 3.4 to 4.6 carats per 100 tons of kimberlite ore. 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 employs about 25 people at full production.

Other Diamond Prospects in the State Line District

In early 2001, Consolidated Pacific Bay Minerals Ltd. of Vancouver, British Columbia, announced its intentions to acquire three diamond prospects in the State Line district of Larimer County from Diamond-X LLC, a Denver-based company, who staked the prospects in 1992. The three prospects are the George Creek, Pearl Creek, and Sand Creek properties. These properties were previously prospected and tested in the late 1970s and early 1980s by a joint venture between Superior Oil and Lac Minerals. The Superior-Lac joint venture also constructed a 50-ton-per-day pilot plant near the Sloan kimberlite in the same district.

Figure 47. Rhodochrosite specimen from the Sweet Home Mine, Park County (specimen courtesy of Dave Bunk, photo by Jeff Scovil).

A March 2001 press release by Consolidated Pacific Bay Minerals Ltd. highlighted previous bulk sample results and other exploration results from the three prospects. At George Creek, a 3,000 ton surface sample in 1984 yielded 89,155 macrodiamonds weighing a total of 1,700 carats. Macrodiamonds are those greater than 0.5 mm in diameter. One diamond weighed 2.14 carats. The diamonds occur in a one-mile-long kimberlite dike averaging about five feet thick. This deposit was discovered through a stream sediment sampling program implemented by Dr. Kenneth Shaver of Westminster, Colorado, who was the chief consulting geologist for the Superior Oil and Lac Minerals joint venture at the time. At Pearl Creek, another kimberlite dike, a composite surface sample totaling 114 pounds yielded three macrodiamonds. At the Sand Creek prospect, no bulk sampling has been carried out. However, indicator minerals found in stream sediment samples and geophysical tests have outlined anomalies similar to George Creek and Pearl Creek. No additional information regarding activity at the prospects has been made public since March 2001, and it is not known as of this writing if additional exploration work is planned.

Rhodochrosite—Colorado's New State Mineral

In April 2002, Governor Owens signed a bill making rhodochrosite the official State Mineral of Colorado. The Sweet Home Mine near the town of Alma in Park County continues to produce specimen-quality rhodochrosite crystals (Figure 47 and cover). 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. Rhodochrosite was once ground up for use as face powder. In the early mining days in Park County, miners discarded the red mineral as waste while they mined silver ore.

The idea to make rhodochrosite the State Mineral originally came from teacher John Ghist’s earth-science class at Platt Canyon High School in Park County. The bill’s principal sponsors were representative Carl Miller, a Leadville Democrat, and Ken Chlouber, a Republican also from Leadville. Both legislators were formerly miners in the Leadville area.

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 are found in the Pikes Peak region and 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.

MINERAL RESOURCE PUBLICATIONS FROM THE COLORADO GEOLOGICAL SURVEY—NEW IN 2001

Non-Fuel Minerals

Geology and Mineral Resources of Park County, Colorado

Resource Series 40, L. Alex Scarbrough, Jr., 2001

This report was written to describe the geological setting and to depict the various mineral and mineral fuel deposits of Park County. The report includes sections on stratigraphy, structural geology, mines and prospects, coal resources, petroleum resources, geothermal resources, areas of possible mineral potential, environmental geology, selected references, and additional reading. 83 pages. 14 figures. 21 tables. 2 plates (1:100,000). Includes one CD-ROM of Park County MRDS data.

Database of Geochemical Analyses of Carbonate Rocks in Colorado

Information Series 57, Beth L. Widmann and James A. Cappa, 2001

Provides a list of known geochemical analyses for carbonate rocks in Colorado. The database describes sample locations, host information, and the geochemistry of 1,570 carbonate rock samples. Most of the sample analyses were gathered from published literature. Other sources include theses, dissertations and other unpublished materials. CD-ROM.

Digital Inventory of Industrial Mineral Mines and Mine Permit Locations in Colorado

Information Series 62, John W. Keller, Randal C. Phillips, and Karen S. Morgan, 2002

This CD publication consists of new GIS shapefiles showing the locations and commodities of all industrial mineral mines (including sand and gravel pits) in the state. The databases of the mines and permits are also included as Excel® spreadsheets. Also included is a color shaded relief map, city and town shapes, roads, railroads, and other pertinent GIS shapefiles. CD-ROM

Oil and Gas

The Coalbed Methane Potential in the Upper Cretaceous to Early Tertiary Laramie and Denver Formations, Denver Basin, Colorado

Open-File Report 01-17, Laura L. Wray, and Nicole V. Koenig, 2001

A compilation of existing geologic information regarding the coalbed methane resources of the Denver Basin into GIS format. Contains chemical, physical, structural, and stratigraphic data on Denver Basin coal beds. CD-ROM.

Late Cretaceous Fruitland Formation Geologic Mapping, Outcrop Measured Sections, and Subsurface Stratigraphic Cross Sections, Northern La Plata County

Open-File Report 00-18, Laura L. Wray, 2000

Describes the surface and near outcrop subsurface extent of the coal beds within the Fruitland Formation in the northern San Juan Basin. CD-ROM.

Coal

Colorado Coal Directory, 2000

Information Series 55, Christopher J. Carroll and Beth L. Widmann, 2001

Describes and lists all of the active coal mines in the state. Includes information on production, location, ownership, geology, and coal quality. Includes a map showing mines, power plants, and transportation systems.

Coal and Coalbed Methane in Colorado

Special Publication 51, Educational CD-ROM, Colorado Geological Survey

This interactive CD-ROM is intended for middle school students. Written to conform to the Colorado Model Content Standards for Earth and Space Science (Standard No. 4). **FREE COPIES** provided for Colorado teachers.

State Land Mineral and Mineral Fuel Potential

The Colorado Geological Survey continues its series of reports that inventory and evaluate the mineral and mineral fuel resource potential of the 4,000,000+ acres of state lands administered by the State Land Board. These reports, in CD-ROM format, include a general summary of the geology and mineral potential of each county along with maps of tract locations, oil and gas tests, mines, and mineral prospects. The main body of the report contains evaluations of individual tracts. The reports and maps are in Adobe Acrobat® format and easily printable. The following counties are currently available:

- Alamosa
- Boulder
- Chaffee
- Cheyenne
- Clear Creek
- Conejos
- Custer
- Dolores
- Fremont
- Gilpin
- Grand
- Gunnison
- Huerfano
- Jackson
- Jefferson
- Kiowa
- Kit Carson
- Lake
- Larimer
- Logan
- Moffat
- Montezuma
- Otero
- Park
- Phillips
- Pitkin
- Prowers
- Rio Grande
- Saguache
- Sedgwick
- Summit
- Teller
- Yuma

Mines and Environmental Geology

History, Geology, and Environmental Setting of the Tweed Mine, Pike/San Isabel National Forest, Chaffee County, Colorado

Open-File Report 01-11, R.H. Wood II and J. Neubert, 2002

This CD-ROM describes the history, geology, and environmental setting of the Tweed mine in Chaffee County. Includes: abbreviations and symbols, introduction, location, historical overview, mining history, geology, site description, waste and hazard characteristics, migration pathways, conclusions, references, and appendix.

History, Geology, and Environmental Setting of the Lienhart Mine, Pike/San Isabel National Forest, Chaffee County, Colorado

Open-File Report 01-12, R.H. Wood II and J. Neubert, 2002

This CD-ROM describes the history, geology, and environmental setting of the Lienhart Mine in Chaffee County. Includes: abbreviations and symbols, introduction, site location, mining history, geology, site description, waste and hazard characteristics, migration pathways, conclusions, references, and appendix.

History, Geology, and Environmental Setting of Selected Mines in the Chalk Creek Mining District, Pike/San Isabel National Forest, Chaffee County, Colorado

Open-File Report 01–13, J. Neubert and R.H. Wood II, 2002

This CD-ROM describes the history, geology, and environmental setting of selected mines in the Chalk Creek Mining District, Chaffee County. Mining history, geology, site descriptions, and waste and hazard characteristics are given for each individual mine.

History, Geology, and Environmental Setting of the Griffin and Wilkesbarre Mines, Pike/San Isabel National Forest, Lake County, Colorado

Open-File Report 01-14, J. Neubert and R.H. Wood II, 2002

This CD-ROM describes the history, geology, and environmental setting of the Griffin and Wilkes-Barre mines in Lake County. Includes: abbreviations and symbols, introduction, location, mining history of mines and unpatented claims, geology, site description, waste and hazard characteristics, migration pathways, summary and conclusions, references, and appendix.

For more information go to the Colorado Geological Survey Web site: http://geosurvey.state.co.us