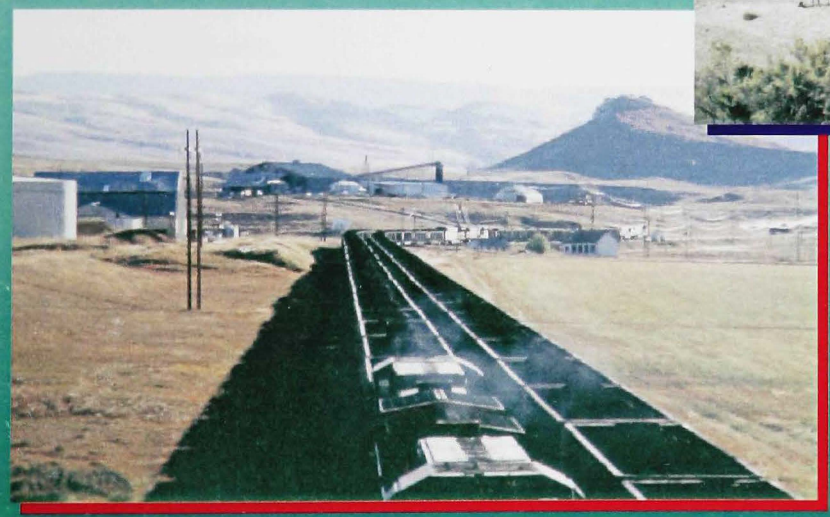
Information Series 59

Colorado Mineral and Mineral Fuel Activity, 2000



By Laura L. Wray,
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James A. Cappa

Colorado Geological Survey / Division of Minerals and Geology / Department of Natural Resources / Denver, Colorado / 2001

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Cover: Cresson gold mine, Teller County; Williams Fork Sandstone gas well in the Piceance Basin west of Rifle; Twentymile coal mine, Routt County

FOREWORD

The purpose of Colorado Geological Survey Information Series 59, *Colorado Mineral and Mineral Fuel Activity, 2000* is to describe exploration, development, and production activity of the gas and oil, coal, and mineral industries of the state in 2000. The report also includes information on the economic impact of these industries to the state. The staff of the Mineral Resources and Geological Mapping 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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INTRODUCTION AND ECONOMIC FACTORS

The Colorado Geological Survey Mineral Resources Section estimates the total value of 2000 mineral and mineral fuel production in Colorado to be $3,833 million dollars, a 35 percent increase from the 1999 total value of $2,835 million (Figure 1).

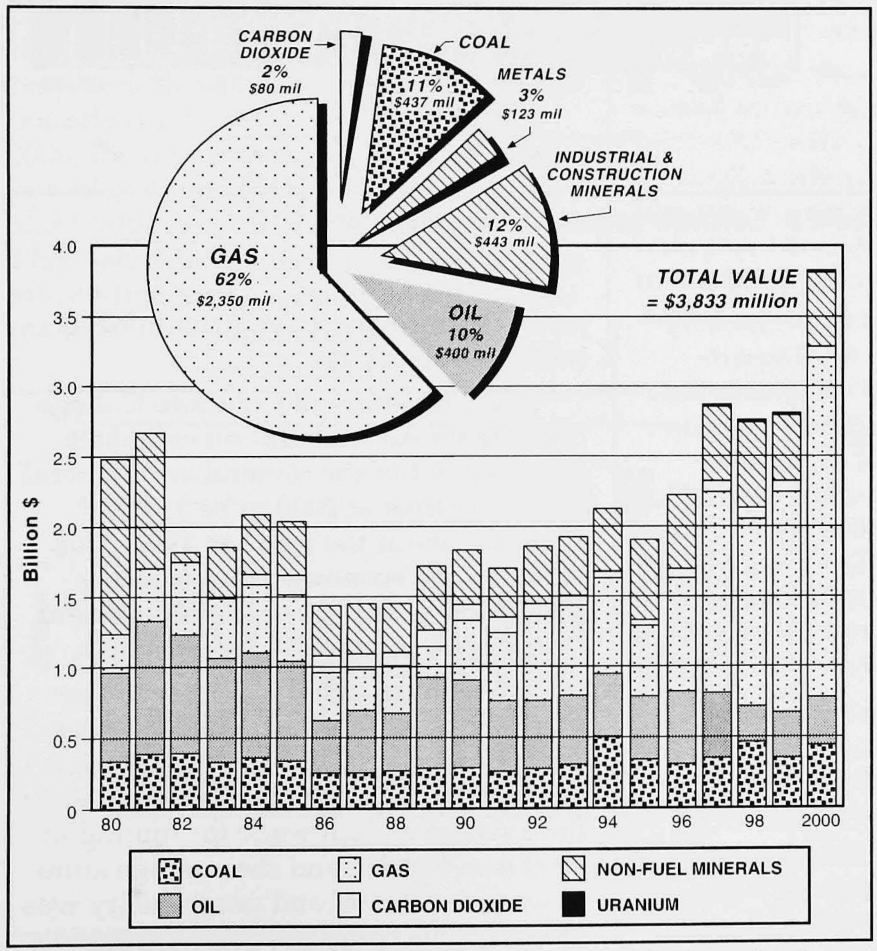

Figure 1. Value of Colorado mineral and mineral fuel production.

Mineral fuel and carbon dioxide production values for 2000 are estimated at:

- oil—$400 million
- natural gas—$2,350 million
- carbon dioxide—$80 million
- uranium and vanadium—$0.5 million
- coal—$437 million

The total value of oil, natural gas, and carbon dioxide production in 1999 was $2,830 million, a 48 percent increase from the 1999 value of $1,909 million. A higher oil and natural gas price is the primary reason for the increase in value for 2000.

Coal production decreased from the 1999 level of 29.9 million tons to 29.1 million tons in 2000. Coal prices, which vary from mine to mine, are estimated at an average $15 per ton for 2000. The value of Colorado coal production is estimated at $437 million.

The U.S. Geological Survey Mineral Information Office estimates the value of the 2000 non-fuel mineral production to be $566 million. This figure is an increase of two percent from the 1999 value of $555 million. The increased value is mostly due to increased production of construction materials.

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 2000 is $45.78 million, a 19 percent increase from the 1999 value of $38.48 million. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (Figure 2).

Severance taxes on mineral and mineral fuel production also provide revenue to state and local governments. According to Colorado law, 50 percent

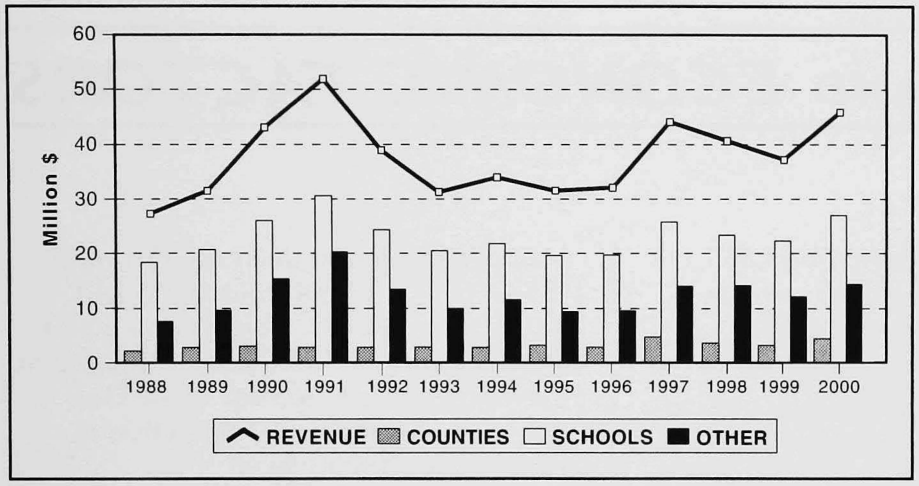

Figure 2. Federal mineral lease revenue and distribution in Colorado.

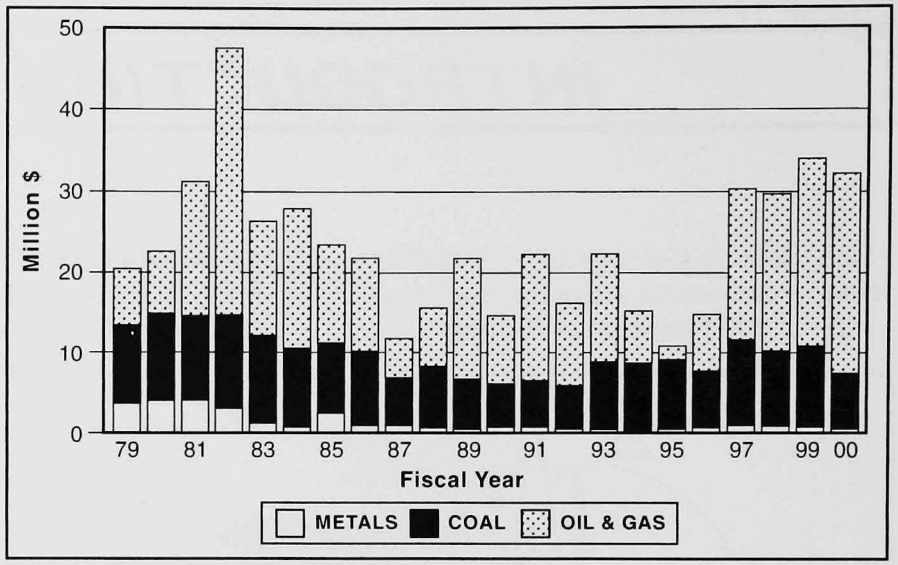

Figure 3. Colorado severance tax collections.

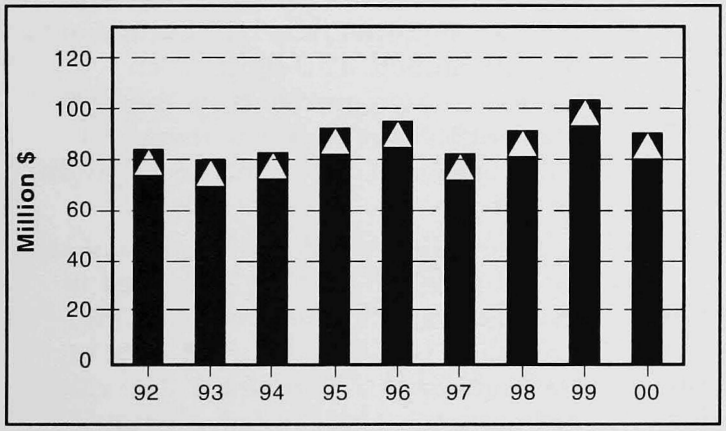

Figure 4. Property tax revenues from mineral properties.

of the severance tax revenue flows to local governments and 50 percent flows into a state trust fund to "replace" depleted natural resources and to complete water projects. Legislation passed in 1996 allows some of the state share of severance tax to be used by agencies within the Department of Natural Resources that promote and regulate the mineral and mineral fuel industries. Severance tax collections in fiscal year 2000 totaled $31.95 million, down six percent from the 1999 severance tax collection of $33.9 million (Figure 3).

Estimated property taxes paid in 2000 to the counties from mineral and mineral fuel properties totaled $90.1 million (Figure 4). La Plata, Weld, and Clear Creek counties all received over $10 million each in mineral property tax revenue. Denver County was the only county that did not receive any revenue from mineral related property tax.

The University of Colorado College of Business Administration estimates employment in the mineral and mineral fuel industries in 2000 to be 13,000 workers, about the same as 1999. This sector of the economy continues a steady ten-year decline in employment from a 1990 level of 21,300 persons.

The mining and oil and gas industries still boast one of the highest average annual wages in the state. According to the Colorado Department of Labor, the average annual wage for mining in 1998 was $58,835 and the average annual wage for the oil and gas industry was $58,012. This compares with Colorado's per capita income for 1998 of $22,821.

GAS AND OIL

Introduction

Colorado, historically recognized for the rich abundance of its many natural resources, is experiencing the economic bounties of its petroleum reserves. In 2000, the total value of gas, oil, and carbon dioxide production is estimated at $2.83 billion, up 55 percent from the 1999 value of $1.8 billion (Figure 5). This astounding jump in value reflects one of the most dramatic years in history to affect the petroleum industry in the state, the nation, and the world. Continuing this staggering increase, the projected value for 2001 is $4.36 billion, a 54 percent increase over the value in 2000.

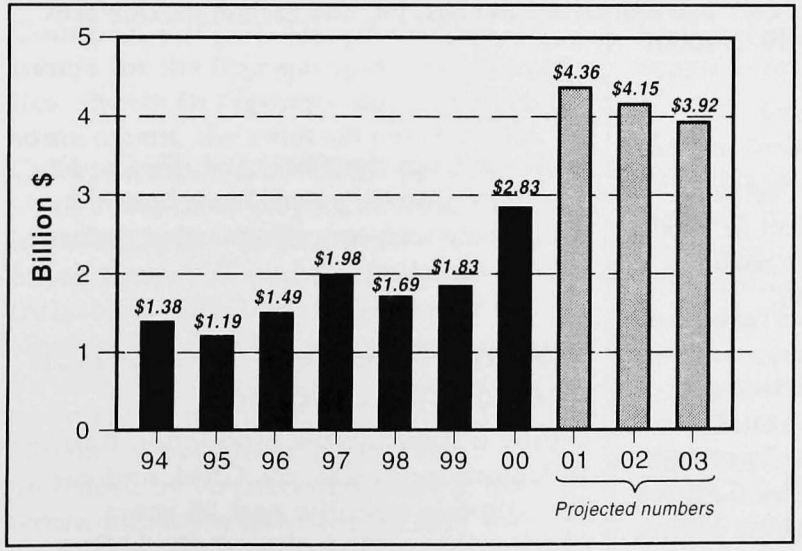

Figure 5. Colorado gas and oil production values 1994-2003.

The petroleum price pendulums soared to new heights in the year 2000, both nationally and in Colorado, causing a frenzied adjustment to several years of low prices and a demoralized petroleum industry. Though crude oil prices climbed to the $40 per barrel level achieved a decade ago during the Gulf War, it was natural gas prices that skyrocketed to over five times their price at the end of 2000, the highest increase in history. Fueled by an increasing demand for natural gas in a booming local and national economy, these price hikes launched many new industry records.

Colorado was well positioned to capitalize on record high prices, upward-spiraling demand for natural gas, and an insufficient delivery infrastructure capable of supplying the levels demanded at reasonable prices. This combination of economic parameters created two geologic bonuses for the Colorado petroleum industry. First, there are now financially compelling reasons to explore for the vast natural gas resources known to exist in the southern Rocky Mountain reservoirs, estimated by the National Petroleum Council to be 388 trillion cubic feet (TCF) of recoverable gas. Since only approximately 18 percent of those known reserves have been produced, the region contains 330 TCF of reserves yet to be recovered. Many of these gas-rich reservoirs are in Colorado and are considered less developed than on-shore Gulf Coast, Mid-continent, and Gulf of Mexico reservoirs, which have been depleted by 58, 54, and 30 percents respectively. Second, unlike oil, almost 87 percent of the gas consumed in the U.S. is produced in the U.S. Since 75 percent of the U.S. natural gas supply is now produced by independents and because the gas reserves in the Rocky Mountains are so abundant, the future for Colorado's independents is, indeed, bright.

The following summary of Colorado petroleum statistics for the year 2000 measures the ways in which the industry

was able to respond to dramatic economic factors.

Colorado Production Statistics*

Year-end numbers for 1999 and 2000 have not been finalized, although some projections can be made. The final 1999 year-end numbers, compiled by the Colorado Oil and Gas Conservation Commission (COGCC), portends the beginning of the dramatic recovery in the petroleum industry that in 2000 would break price and demand records for natural gas.

Natural Gas

Continuing a steady upward climb, 724 billion cubic feet (BCF) of natural gas, worth $1.5 billion dollars was produced in Colorado in 1999. This represented a 3 percent increase over the 1998 total of 704 BCF. The projected total for 2000 is 740 BCF, a 2 percent increase from 1999 (Figure 6).

Of the 724 BCF of natural gas produced in 1999, 394 BCF of that was derived from methane contained in subsurface coal beds. This resource, known as coalbed methane (CBM), is an increasingly important resource in Colorado. CBM production in 1999 rose 2 percent over the 1998 totals of 387 BCF, and contributed $803 million in revenues to the state. The expected CBM totals for 2000 are approximately 385 BCF, a 2 percent decrease from the 1999 production volumes (Figure 7). This decrease probably represents the industry's inability to replace declining production with new production because of an inadequate supply of available rigs and crews.

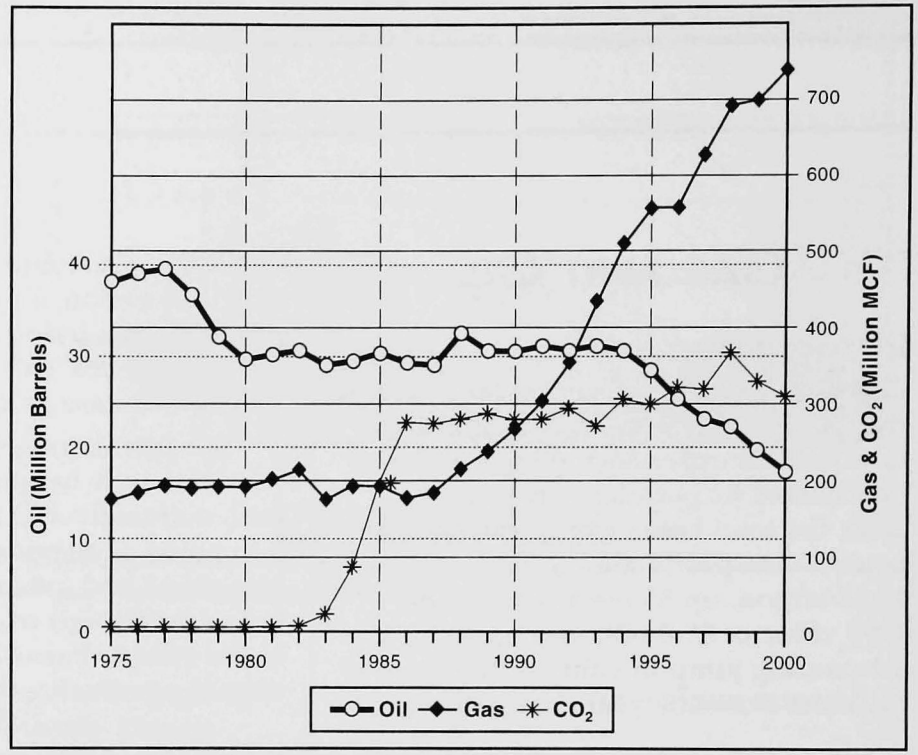

Figure 6. Colorado annual natural gas, oil, and carbon dioxide production, 1975-2000.

Crude Oil

Continuing the slow decline in oil production that has occurred since 1994, a total of 19.1 million barrels of oil (MMBO), worth $334 million, was produced in 1999, a 15.1 percent decrease from the 1998 amount of 22.5 MMBO. The projected volume for oil production in 2000 is 17.3 MMBO, a 10 percent decrease from the 1999 amount (Figure 6).

Carbon Dioxide

Annual carbon dioxide production for 1999, worth $85 million in revenues to the state, totaled 304.7 BCF, a 17 percent decline from the 1998 total of 367.7 BCF. The projected production total for 2000 is 310 BCF, representing a 2 percent increase from the 1999 total (Figure 6). Higher crude oil prices have boosted secondary recovery efforts using carbon dioxide injection.

Twenty-Five-Year Production Trends for Colorado

Figure 6 summarizes production figures in Colorado for gas, oil, CBM, and carbon dioxide over the past 25 years. During this period of time, the U.S. petroleum industry experienced several

*Provided by the Colorado Oil and Gas Conservation Commission (COGCC)

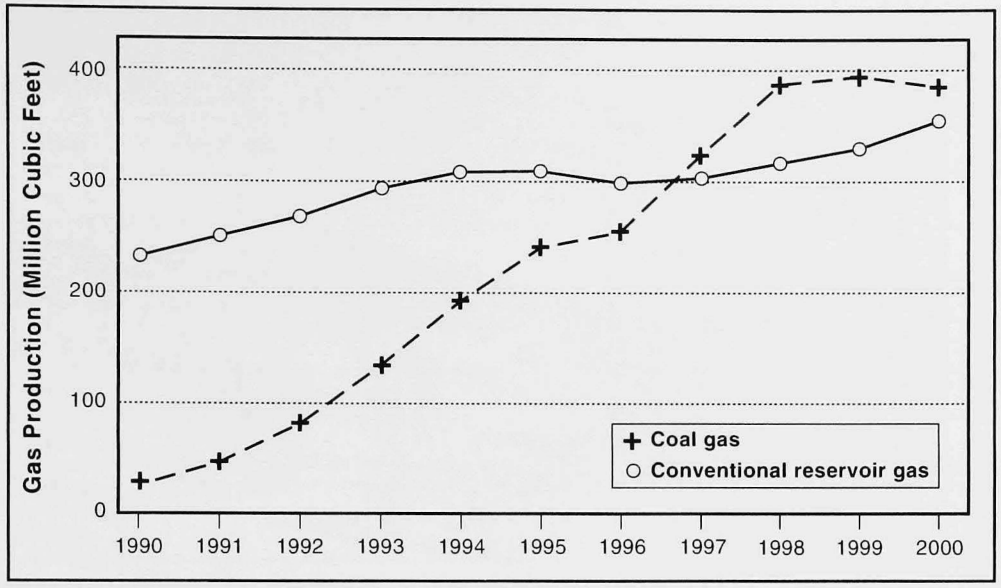

Figure 7. Coalbed methane and conventional reservoir gas production.

boom and bust cycles that were controlled primarily by changes in pricing and production quotas set by the Organization of Petroleum Exporting Countries (OPEC). The production trends for the four gas and oil commodities, shown in Figures 6 and 7, reflect, to some extent, the external effects upon Colorado created by OPEC policies. Until 1986, most oil production, including OPEC oil, was sold at fixed prices based upon U.S. and foreign price controls. Non-OPEC producers in the Third World were able to produce only enough for their domestic consumption. In the early 1980s, however, Third World and North Sea petroleum production increased by 66 percent, flooding the world market with crude oil that was sold at market prices. Price controls failed and spot market sales began to assume a more dominant role in the oil market (Lynch, 2001, *Oil & Gas Journal*, Feb. 12, 2001, p. 20). One year later, in 1987, natural gas production in Colorado began to take off (Figure 6).

In Colorado, oil production began to decline from a high of 39.5 MMBO in 1977 (Figure 6). There were no major discoveries made in Colorado after 1977 that could effectively replace oil reserves being produced. Additionally, major company exploration dollars began to flow overseas in the early 1980s as the search for the large hydrocarbon accumulations, fondly referred to as "hunting for elephants", was diverted to international opportunities. Colorado producers were able to achieve a flat production rate for almost 15 years through careful hydrocarbon reservoir management (secondary and tertiary recovery techniques, new fracture stimulations, recompletions, and infill drilling with improved drilling and completion technologies). However, the ultimate lack of new major field discoveries resulted in the eventual decline of the state's oil field production that started in 1978 and continues through 2000.

The oil embargo of 1973 placed the issue of U.S. dependence on foreign oil on the national radar screen. Natural gas, an alternative fuel to crude oil, did not become a viable energy alternative until three economic factors changed ten years later in 1983. First, many 20-year price contracts for natural gas were renegotiated, raising the price of natural gas as much as ten times. Second, natural gas became touted as a more environmentally friendly energy source. Third, though large, undiscovered oil accumulations seemed scarce in the U.S., abundant reserves of domestic natural gas were identified. Production of natural gas nationally, as well as in Colorado (Figure 6), has been on the rise since 1983 following the recognition of those three emerging realities.

Coalbed methane (CBM) is natural gas that is produced specifically from subsurface coal beds that contain significant quantities of methane gas. Long considered an undesirable and dangerous by-product of many Colorado coals, this colorless and odorless gas, often capable of spontaneous combustion,

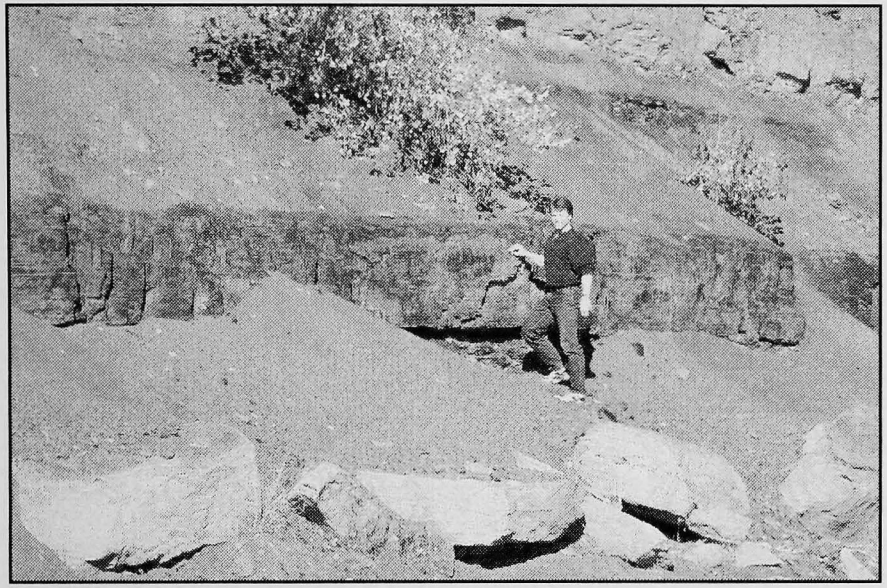

Figure 8. Three-foot coal seam in the Raton Formation, Raton Basin, south central Colorado (photograph courtesy of Robert Mueller, Barrett Resources).

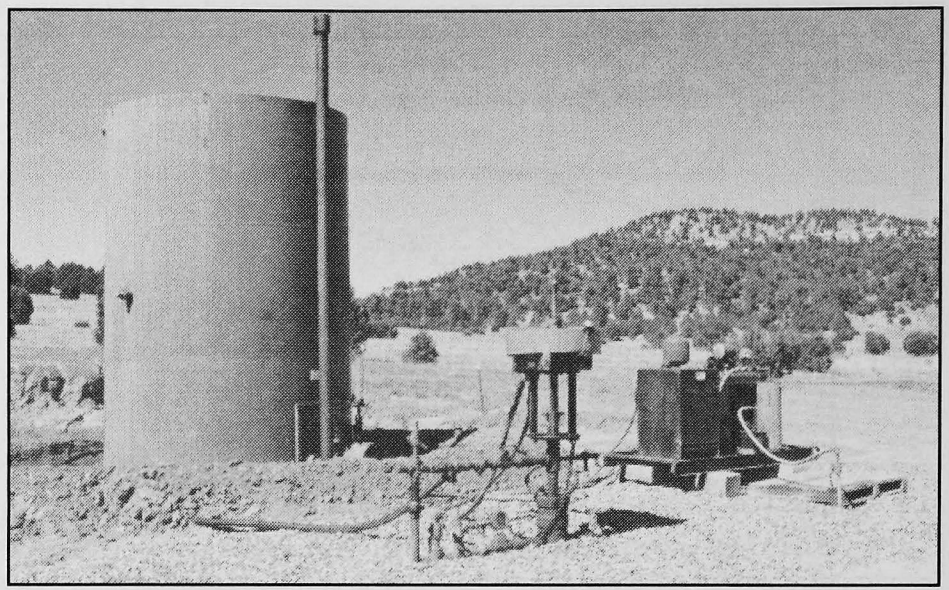

Figure 9. Evergreen Resources CBM production in the Raton Basin (photograph courtesy of Dennis Henry, Digital MediaVision).

was responsible for many coal fires and mine explosions. The petroleum industry, in conjunction with state and Federal agencies, developed techniques to extract methane from coal beds using drill rigs and subsurface completion technologies similar to what is used to produce natural gas from conventional reservoirs, predominantly sandstones and limestones. Coal beds were identified as unconventional gas reservoirs, subject to tax credits in the late 1980s and early 1990s. Though the tax credits provided the initial economic impetus to explore for these unconventional reservoirs, successful drilling and completion technologies allowed the extraction of CBM to become fully profitable even after the tax credits expired in the early 1990s. Figure 8 shows a three-foot coal from the Raton Formation in the Raton Basin of south central Colorado that produces methane gas in the subsurface. A typical Raton Basin coalbed methane production unit is shown in Figure 9.

Figures 6 and 7 and Table 1 show the recent impact of CBM production in Colorado. The volume of CBM is combined graphically with natural gas, shown as the total gas volume in Figure 6, because the two gas streams from both conventional gas reservoirs and CBM reservoirs are similar compositionally and are, in most cases, priced identically. Figure 7 shows the breakdown of CBM and conventional gas production. The separate production numbers have only been recorded for the past decade. Before that time, it is probable that a small portion of conventional gas production was actually attributable to coalbed methane.

Table 1 shows a comparison of reserves and production between the three major CBM-producing states, Colorado, New Mexico, and Alabama, from 1989 through 1999. For the first time ever, Colorado holds first place in proved CBM reserves, edging by New Mexico who has held the lead for the past decade.

Table 1. U.S. coalbed methane proved reserves and production, 1989-99 in billion cubic feet at 14.73 pounds per square inch absolute and 60° F (from Energy Information Administration, *1999 Annual Report*, p. 35).

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

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

Annual production of carbon dioxide was on a gradual decline from a high of 368 BCF in 1998 (Figure 6). The 1999 production was 304.7 BCF. The projected 2000 total is 310 BCF. As with Colorado crude oil reservoirs, carbon dioxide reservoirs exhibit a natural decline associated with yearly production. Since no new reservoirs have been discovered in Colorado in recent years, there is no new production to replace the depleting reserves. However, the demand for carbon dioxide in secondary recovery efforts in response to higher crude oil prices should cause an increase in carbon dioxide production for 2000.

Top County Producers

In the natural gas production arena, 33 Colorado counties contributed to 1999 gas production, including coalbed methane production (Figure 10). The top three gas-producing counties in 1999 and in cumulative production are La Plata County, Weld County, and Garfield County (Table 2).

The bulk of the natural gas production in 1999, totaling 365 BCF, was derived from the Late Cretaceous Fruitland Formation coals of the Ignacio-Blanco field in the San Juan Basin in La Plata County. Other prolific gas reservoirs in the San Juan Basin include the Dakota and Mesaverde sandstones, totaling 43 BCF.

Table 2. Top three natural gas producing counties in Colorado in 1999 (MCF = thousand cubic feet).

Rating	County	Annual Gas Prod., MCF	Cum. Gas Prod., MCF
1	La Plata	408,351,000	3,412,293,189
2	Weld	124,355,801	2,138,633,355
3	Garfield	56,084,467	460,443,385

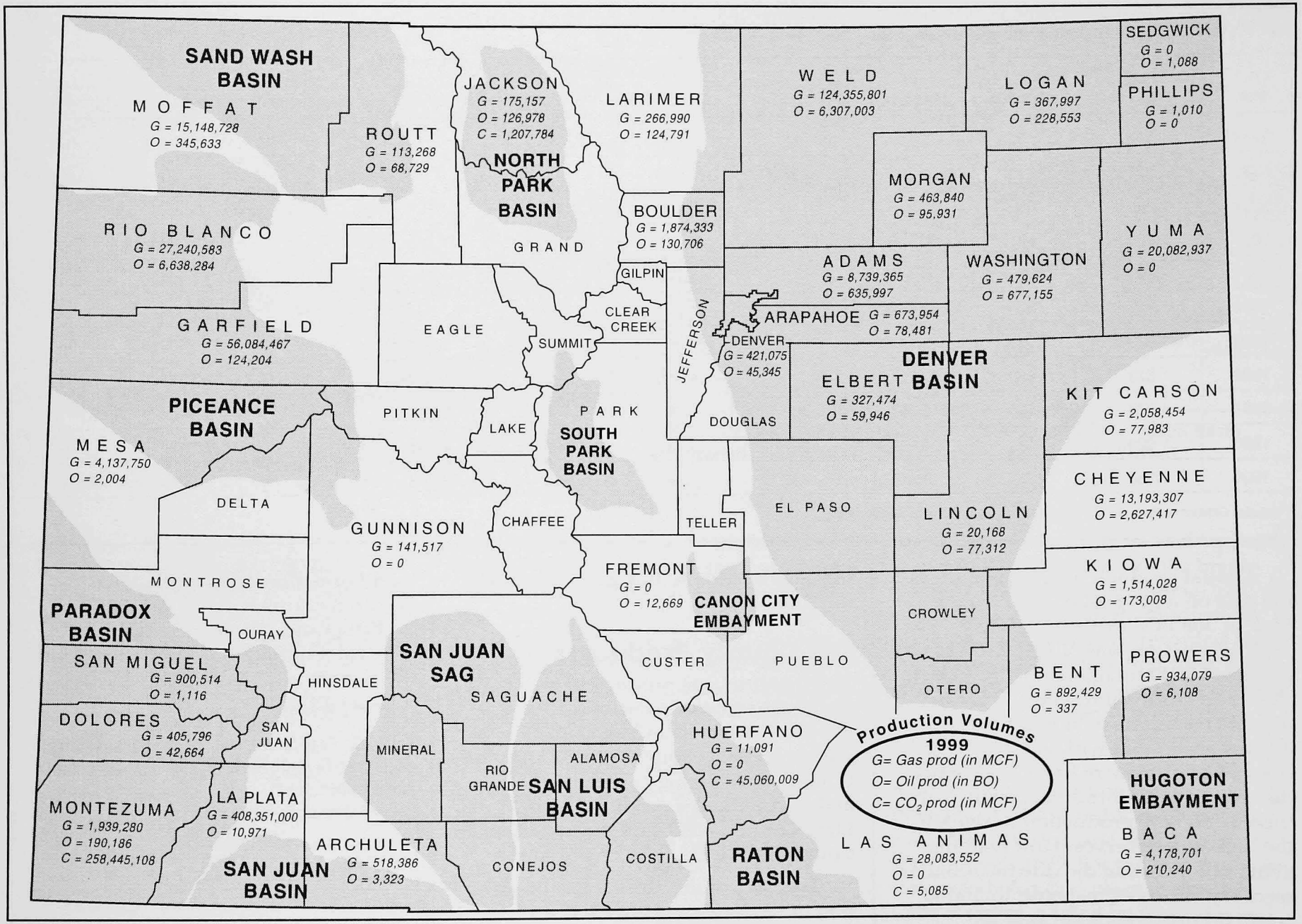

Figure 10. 1999 production volumes for Colorado counties (data from COGCC).

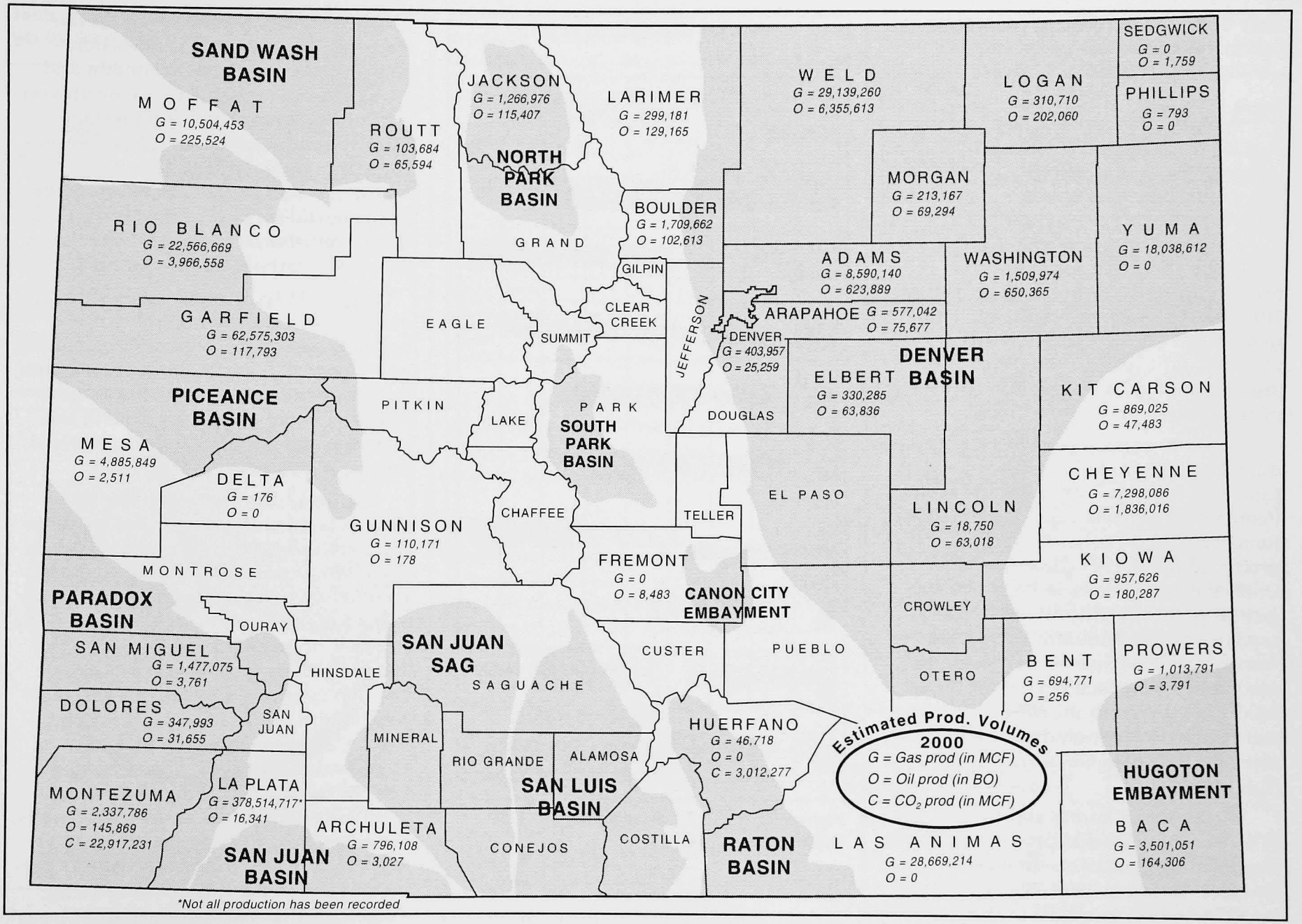

Figure 11. Estimated 2000 production volumes for Colorado counties (data from COGCC).

Table 3. Top 3 oil producing counties in Colo in 1999 (BO = barrels of oil).

Rating	County	Annual Oil Prod., BO	Cum. Oil Prod., BO
1	Rio Blanco	6,638,284	935,466,305
2	Weld	6,307,003	190,560,235
3	Cheyenne	2,627,417	76,869,599

Thirty Colorado counties contributed to 1999 oil production (Figure 10). The top three oil-producing counties are Rio Blanco County, Weld County, and Cheyenne County. These are also the top three counties in terms of cumulative production (Table 3).

Thirty five percent of the oil produced in 1999 came from Rio Blanco County, predominantly from the Permo-Pennsylvanian Weber Sandstone in the Rangely field. Another 33 percent of the produced oil in 1999 came from the Cretaceous reservoirs in Weld County including: the Muddy (J) and Codell sandstones, the Niobrara Formation "chalk", and the Sussex and Shannon sandstones. Fourteen percent of the oil produced was from the Mississippian and Pennsylvanian sandstone and limestone reservoirs in Cheyenne County (Table 3).

Montezuma County contributed 258 BCF of carbon dioxide production, a full 85 percent of the state's total carbon dioxide volume in 1999. The Mississippian Leadville Limestone in the county's McElmo Dome field supplies carbon dioxide that is transported by pipeline to west Texas for secondary recovery of heavy oil reserves in the Permian Basin by means of carbon dioxide injection. Dike Mountain and Sheep Mountain fields in the northwest part of the Raton Basin in Huerfano County produced almost 15 percent of the state's total. Jackson County's McCallum and McCallum South fields in the northeast part of the North Park Basin contributed less than 1 percent of the state's carbon dioxide production.

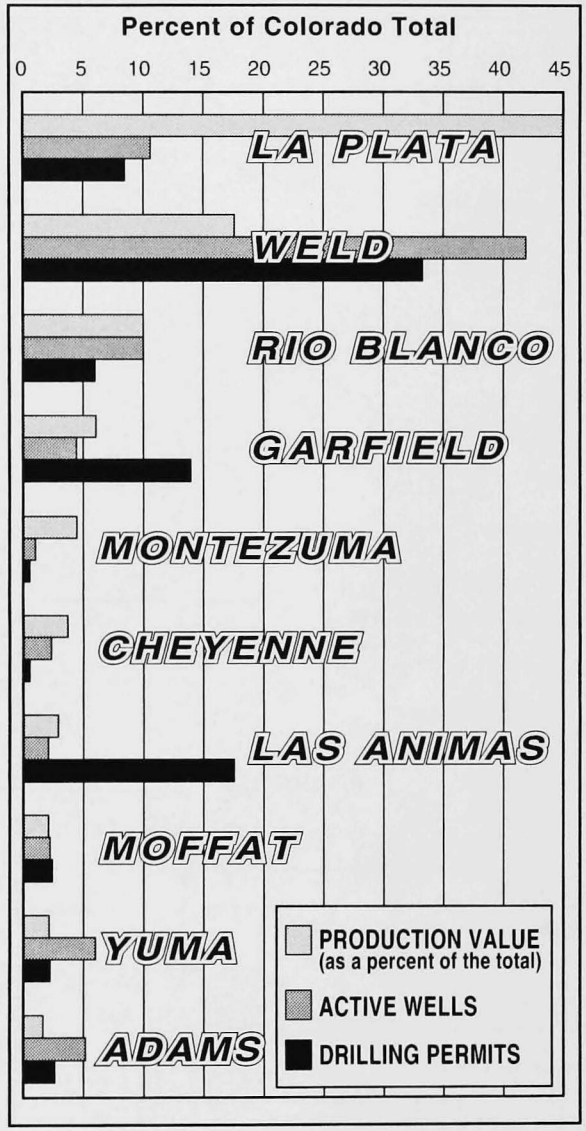

Figure 12. Top 10 Colorado oil and gas counties by value.

Figure 11 (p. 9) shows the estimated production volumes for 2000 for the gas-, oil- and carbon dioxide- producing counties in Colorado. Production numbers for certain areas of the state have not been submitted at the time of this report so the numbers must be viewed only as estimates.

Figure 12 shows the top ten Colorado oil and gas counties by value for 1999 and 2000. This chart shows an interesting comparison between the production value and number of active wells for each county in 1999 versus the number of drilling permits issued for those counties in 2000. In comparing the two counties that provide the most production to the state, La Plata and Weld Counties, note that La Plata County delivers approximately 45 percent of the state's production value with only 10 percent of the active wells, whereas Weld County produces about 42 percent of the value but with 33 percent of the wells. It is not surprising, therefore, that Weld County had the highest number of drilling permits in

Table 4. Colorado consumption of natural gas by sector in 1998.

Sector	1998 Natural Gas Consumption (Bcf)	Percent of Total Natural Gas Production
Residential	111	15.7
Industrial	87	12.3
Commercial	63	8.9
Lease, pipeline, & plant fuel	40	5.7
Electric utilities	11	1.6
Export out of state	393	55.7
Total	**705**	**99.9**

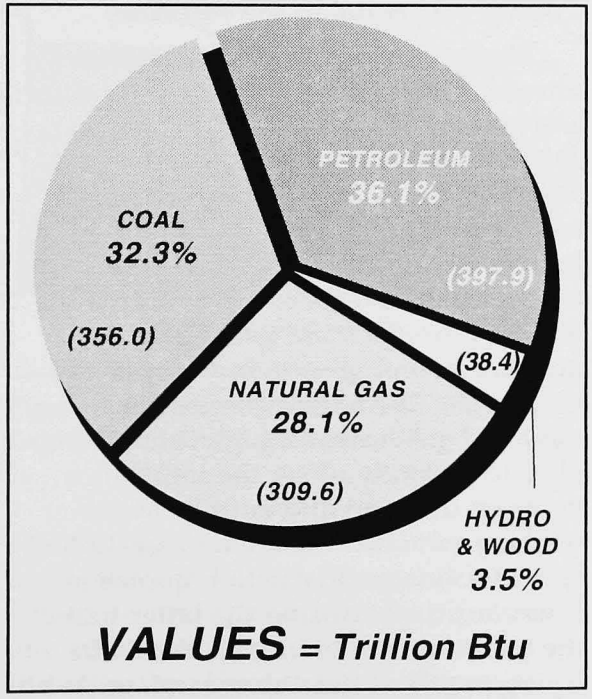

Figure 13. Energy source consumption in Colorado.

Table 5. Colorado consumption of refined crude oil by source in 1997.

Type of Use	1997 Consumption (BO)	Percent of Total Consumption
Asphalt and road oil	2,574,000	3.8
Aviation gasoline	143,000	0.2
Diesel	13,796,000	20.3
Jet fuel	7,174,000	10.5
Kerosene	29,000	0.04
Lubricants	642,000	0.9
Motor gasoline	43,744,000	64.2
Residual fuel	3,000	0.004
Total	**68,105,000**	**99.9**

2000. A tighter spacing of gas wells is required in Weld County to achieve a similar production volume as the more widely spaced wells in La Plata County.

Consumption

Eighty-seven percent of natural gas consumption in the U.S. is produced within the U.S. Gas currently accounts for 15 percent of total U.S. electrical generation. Colorado's natural gas consumption by sector in 1998 is listed in Table 4. More recent consumption numbers for the state are not available at the time of this writing.

Refined crude oil consumption in 1997 by Colorado is displayed in Table 5. More recent consumption numbers for the state are not available at the time of this writing. Sources of primary energy consumption are shown in Figure 13.

Commodity Pricing Value

In 2000, the total value for natural gas (including CBM), crude oil, and carbon dioxide in Colorado is estimated at $2,830 million (Table 6). This value represents a 48 percent increase from the 1999 value of $1,909 million.

The estimated value of natural gas and CBM production in the state is $2,350 million, a 58 percent increase from the 1999 value of $1,490 million.

Crude oil value in 2000 is estimated at $400 million, a 20 percent increase from the 1999 value of $334 million.

Table 6. Value of hydrocarbon commodities in Colorado 1998-2000.

Year	Value of Natural Gas and 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	2,350 (58% increase)	400 (e) (20% increase)	80 (e) (6% decrease)	2,830 (e) (48% increase)

(e) = estimated

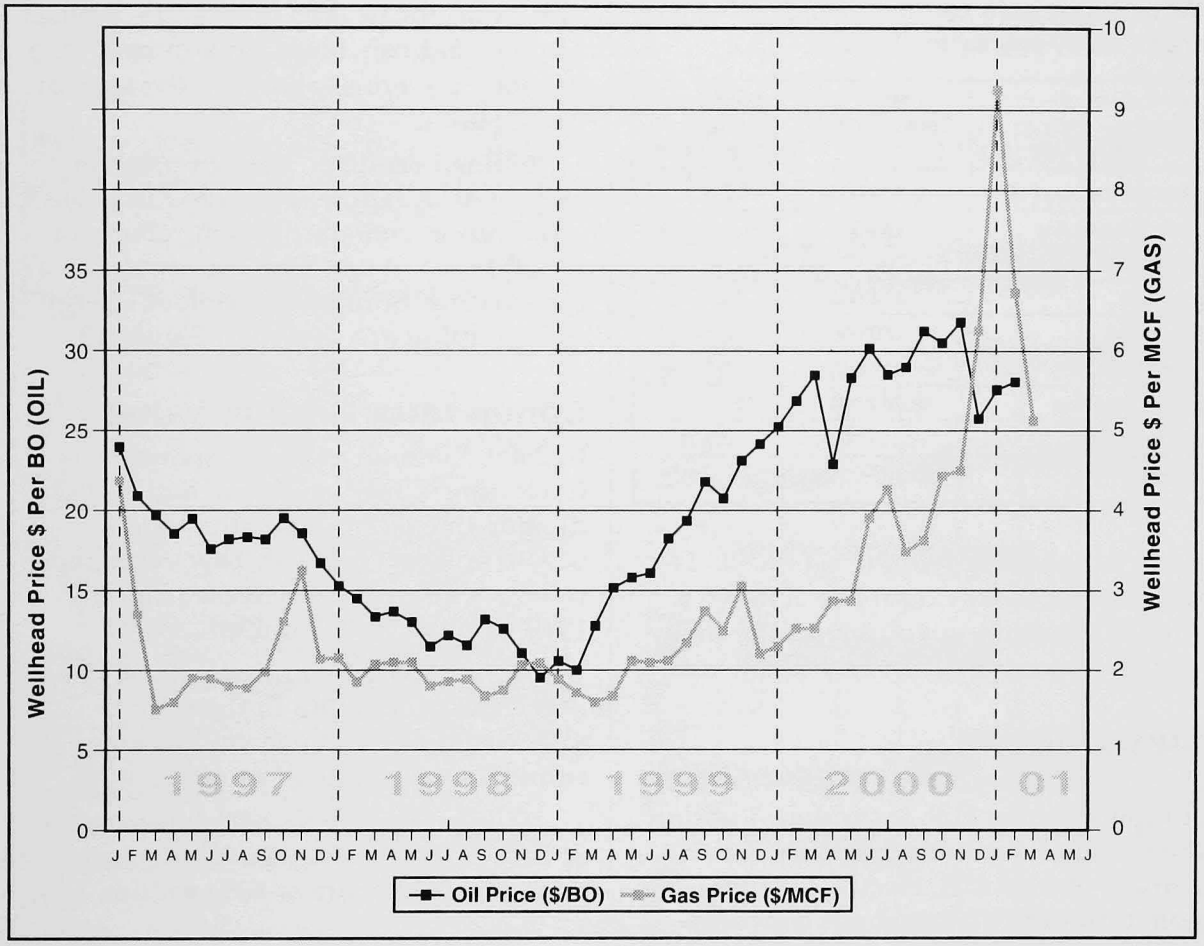

Figure 14. Colorado gas and oil monthly wellhead price index 1997 through first quarter 2001.

The value of carbon dioxide is estimated to fall by 6 percent in 2000 to $80 million from 1999's value of $85 million.

Monthly wellhead prices from 1998 through 2000 (Figure 14) shows the dramatic leap in prices that were reflective of the worldwide market. The annual average composite price in Colorado for its petroleum products changed accordingly: from 1999 to 2000, natural gas prices per thousand cubic feet (MCF) rose 52 percent from $2.04 to $3.11; crude oil prices per barrel of oil (BO) increased 45 percent from $16.54 to $24.00; and carbon dioxide prices per MCF rose 12 percent from $0.25 to $0.28. Note the all-time high price of greater than $9.00 per MCF for natural gas in Colorado at the beginning of 2001!

Figure 15 shows estimated values for gas and oil production for individual counties in 1999. The top three counties producing the most income from their gas and oil activities are: La Plata ($841 million), Weld ($321 million), and Rio Blanco ($180 million). These numbers vary somewhat from the estimated values published in last year's annual report. La Plata County exceeded the estimate by $71 million; Weld County fell short of the estimate by $54 million; and the actual value in Rio Blanco County was equal to the estimate.

These commodity price increases mirrored those for both the U.S. and for world markets. Domestically, the year 2000 was beset with the coldest November and December in recorded history in many parts of the country. Industrial and commercial demand for heating fuels overloaded an increasing demand for electrical generation to power a booming economy across the U.S. In late 2000, the government removed gas from strategic storage supplies to partially offset the imbalance between demand and supply. Meanwhile, on the international stage, OPEC agreed to lower production quotas at least four times during the latter half of the year to boost prices, all the while trying to adjust the volumes of crude oil supplied by Iraq through legal and illegal markets. Having emerged from

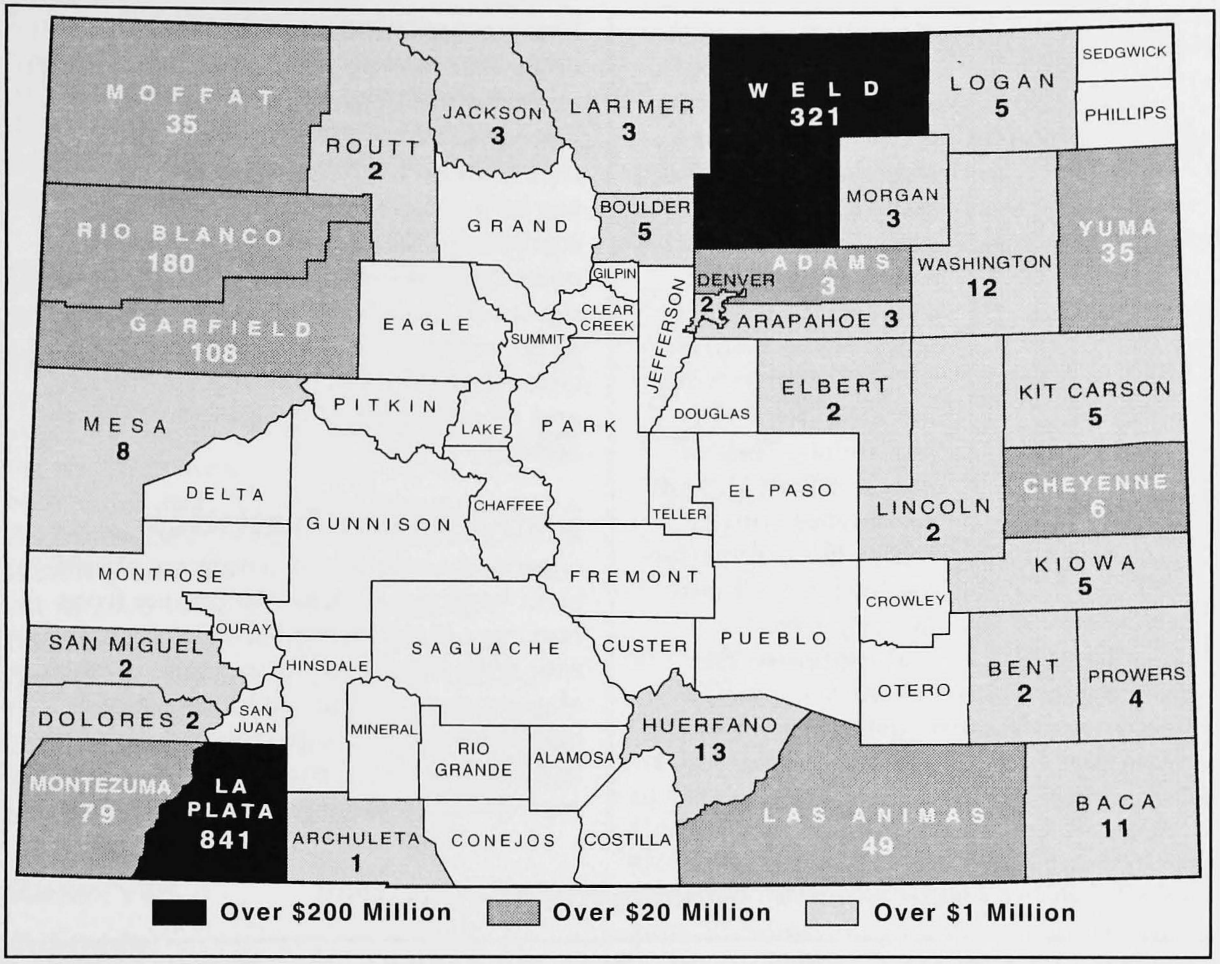

Figure 15. Estimated gas and oil production values for Colorado counties, 1999 (data from Colorado Oil and Gas Conservation Commission).

several years of low commodity prices and delays in both drilling and infrastructure projects (especially pipelines and refineries), the domestic petroleum industry was hamstrung to respond more quickly to the increasing demand. As a result, prices spiraled upward in 2000 as the industry scrambled to furnish the supplies to meet that demand. The intricate interplay of demand, supply, price, and distribution has no easy solutions for guaranteeing plentiful and affordable energy supplies in the future.

Drilling Permits and Drilling Activity

The petroleum industry in Colorado hastened to capitalize on higher commodity prices by increasing drilling activity. In 2000, a record number of 1,529 drilling permits or "APDs" (Applications for Permit to Drill) were approved by the COGCC. This was a staggering 50 percent increase over the 1999 approved APDs of 1,010. Based upon this level of activity, the COGCC forecasts a total of 2,400 APDs during calendar year 2001 (Figure 16).

In 2000, the top 5 counties with numbers of APDs shown in parentheses, are: Weld County (509), Las Animas County (268), Garfield County (213), La Plata County (127), and Rio Blanco County (89) (Table 7).

In 1999, the following wildcat wells were drilled with the percentage change from the 1998 numbers in parentheses: 41 gas wells (+293 percent); 9 oil wells (+50 percent); and 39 dry holes (-22 percent). The following development wells are listed in a similar manner: 456 gas wells (-11 percent); 162 oil wells (+1,157 percent); and 53 dry holes (-10.2 percent). The total number of producing gas and oil wells in the state at the end of 1999 was 18,473, a 6 percent increase over the number at the end of 1998.

Daily national rig counts increased by 79 percent to 1,118 active onshore and offshore rigs in 2000 from 625 rigs in 1999. In the 11-state Rocky Mountain

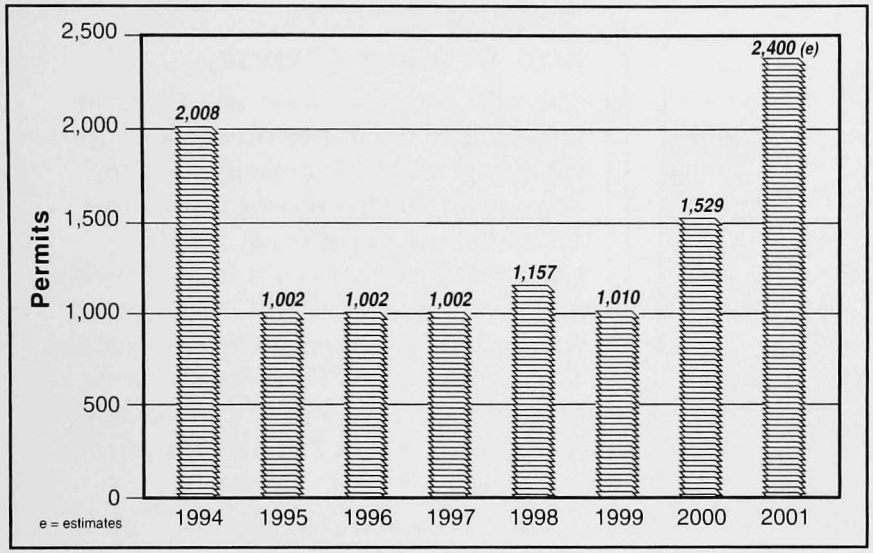

Figure 16. Colorado drilling permits, 1994-2001.

region, the rig count at the end of 2000 was above 130 as compared to a total of 87 at the end of 1999. The Colorado rig count rose to almost 30 at the end of 2000, the state's highest level since January 1995.

Colorado and Rocky Mountain operators were unable to contract enough rigs and rig crews to drill all the permitted locations obtained in 2000. Despite the enormous U.S. demand for energy fuels and the desperate need for serviceable drilling rigs, there are only a finite number of rigs and rig crews that can be employed to meet the increasing demand. Over the past two decades, petroleum companies have been systematically whittling drilling and completion costs to remain competitive. The dismally low petroleum prices reached several times during these twenty years forced catastrophic numbers of personnel layoffs with an accompanied decrease in drilling activities as returns on investments were forced to rock-bottom levels. Tens of thousands of laid-off employees sought retraining opportunities and forged new career paths. Consequently, the pool of qualified workers has now shrunk dramatically just at the time the industry is hoping to ramp up the level of development drilling activity.

Exploration efforts for undiscovered reserves are only now being undertaken cautiously. The net result of this past history is that there is a limit, close to that seen at year-end 2000, to the number of trained staff and serviceable equipment that can be mobilized to meet these development demands. The rig count may be increased by as much as 20 percent if creative solutions enhanced salaries, enticing incentives, and effective training opportunities are offered.

Employment Statistics

Guarded optimism or cautious skepticism kept petroleum companies from boosting their hiring levels commensurate with the five-fold increase in natural gas prices during 2000. Average employment in the petroleum industry in Colorado rose from 7,048 to approximately 7,200 people, an increase of just

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

Year	No. 1	No. 2	No. 3	No. 4	No. 5	Total
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
(+50%)	(+50%)	(+63%)	(+8%)	(-12%)	(+50%)	
2001						2,400 (e)

(e) = estimated

2 percent. In 2001, we predict a continued increase in employment numbers in order to capitalize on exploration and development opportunities that are fueled by continued robust prices and rising energy demands.

Gas and Oil Well Drilling Activity

The drilling activity level across Colorado was high in all four quadrants of the state. Figure 17 shows a map of the state on which is superimposed some of the reservoirs and lithologies being drilled. As might be expected, the major fields in which the drilling activity was the highest in 2000 were in the Denver (DJ) Basin, the Raton Basin, the Piceance Basin, and the San Juan Basin. The top five counties with the highest number of drilling permits submitted over the past three years are located within these four basins (Table 7 and Figure 17).

Reserves

Colorado

Proved dry natural gas reserves in Colorado were estimated at 8,987 BCF at the end of 1999, a 14 percent increase from the 1998 total of 7,881 BCF. A record 118 percent of dry gas production was replaced in 1999, up 43 percent from 1998. Colorado is ranked seventh in the U.S. in proved dry natural gas reserves. Interestingly, the U.S. total discoveries of dry natural gas were down 5 percent from 1998 to 10,807 BCF, due primarily to rapidly depleting gas reserves in the Gulf of Mexico.

Proved crude oil reserves in Colorado were 212 MMBO at the end of 1999, showing no change from the 1998 total of 212 MMBO. Colorado is ranked 11th in U.S. proved crude oil reserves.

United States

As of December 31, 1999, the nation's proved reserves of dry natural gas were 167,406 BCF, a 2 percent increase from 1998's total of 164,041 BCF. The following geographic areas account for 81 percent of these gas reserves: on-shore Gulf of Mexico, deep Gulf of Mexico, Mid-continent, Rocky Mountains, and Alaska.

Year-end 1999 U.S. proved reserves of crude oil were 21.77 billion barrels of oil (BBO), a 3.5 percent increase from 21.03 BBO in 1998. The following areas in the country contribute to the majority of these oil reserves: Alaska, Texas, California, and Gulf of Mexico Federal Offshore. By way of perspective, Colorado's percentage of the nation's proved crude oil reserves at the end of 1999 was just 1 percent.

World

The slow economic recovery in the worldwide petroleum industry, launched in 1999, did generate a modest increase in estimated natural gas and crude oil reserves in 2000. World gas and oil reserves, as well as production increased by 2 to 3 percent. The Oil and Gas Journal estimates that world gas reserves were 5,146 TCF in 2000 and are projected to grow to 5,278 TCF in 2001. World oil reserves climbed to 1.016 trillion barrels of crude oil in 2000 and are estimated to march upwards to 1.028 trillion barrels in 2001. Worldwide gas reserves are rising steadily as well from 5,146 TCF in 2000 to an estimated 5,278 TCF in 2001 (*Oil & Gas Journal*, Dec. 18, 2000, p. 121).

In a survey conducted by the Oil and Gas Journal, countries were requested to report their proved reserves of gas, crude oil, and condensate. The 2000 survey uncovered several significant changes in some or all hydrocarbon components over 1999 figures for Bolivia, Argentina, Thailand, and several European and Middle Eastern countries. Out of the worldwide totals, OPEC reserves account for 79.2 percent of world oil reserves and 44.4 percent of world gas reserves (*Oil and Gas Journal.*, Dec. 18, 2000, p. 121).

News and Developments

Wellhead Prices

The average wellhead price for dry natural gas and crude oil in 1999 were $1.73 per MCF and $17.00 per BO respectively. Estimates for prices in 2000 reflect the dramatic upturn of the petroleum industry; the yearly average gas prices were estimated at $3.75 per MCF and $25.00 per BO for average crude oil prices.

Earnings

Yearly earnings in 2000 for most major petroleum companies increased an

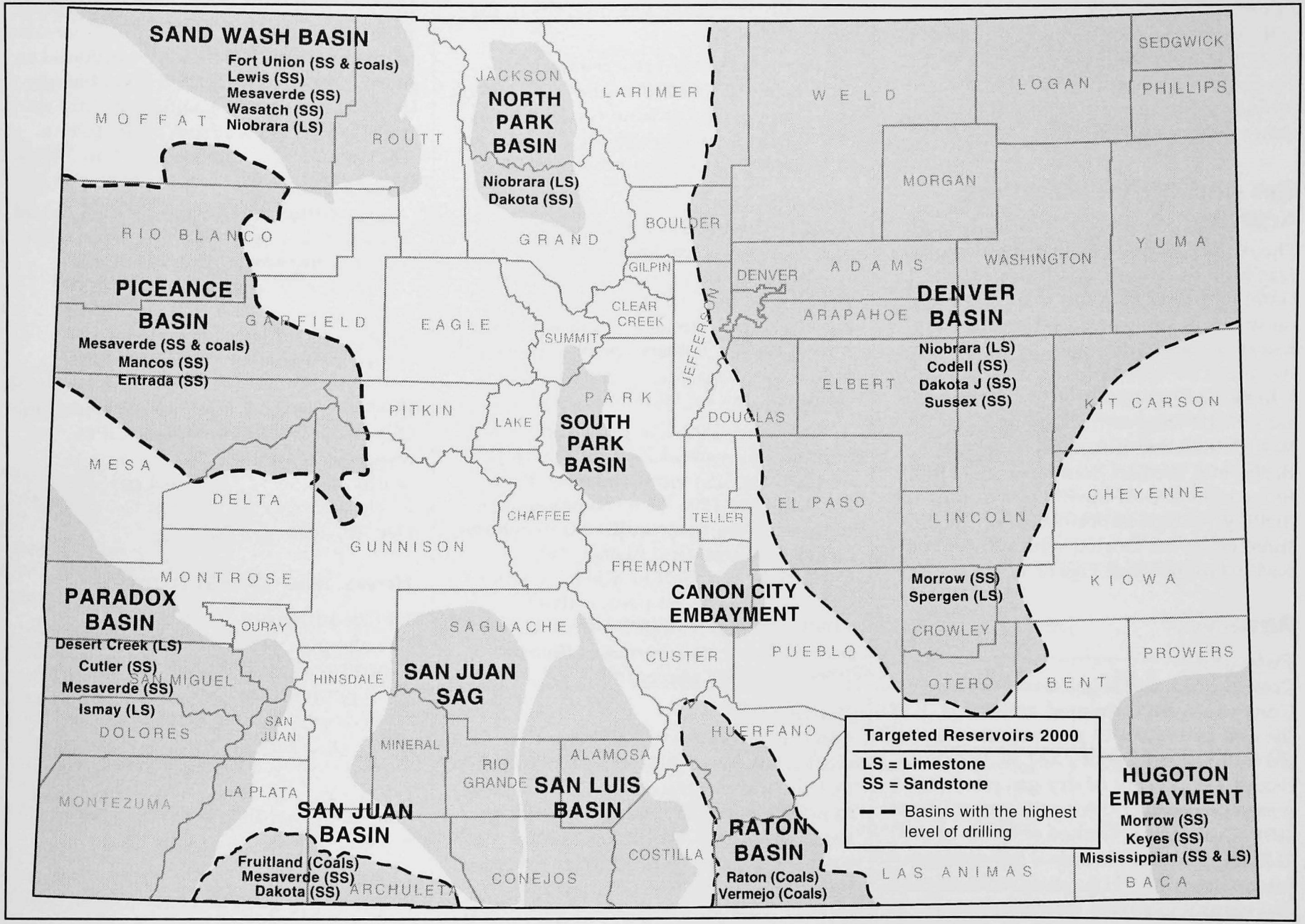

Figure 17. Location map showing drilling activity and targeted reservoirs in 2000.

incredible two to three times over 1999 earnings! Major and independent companies in Colorado experienced similar windfalls, created by the dramatic price hikes that occurred during 2000. In most cases, these companies saw their stock prices rise as well from 13 percent to over 200 percent by the end of 2000 (*IPAMS Wildcatter Weekly, Issue* 7, 2001, p. 16). It is no wonder that estimated capital budget expenditures for 2001 have also increased up to 20 percent (*Oil and Gas Journal.*, Jan. 8, 2001, p. 21).

Infill Drilling Activity

The year 2000 could readily be dubbed "The Year of the Infill Applications in Colorado." Three basins were the focus of extensive infill drilling applications: the San Juan Basin in La Plata County, the Piceance Basin in Garfield and Rio Blanco Counties, and the DJ Basin in several northeastern Colorado counties. In La Plata County, an industry consortium filed one comprehensive application for over 600 infill locations for the Cretaceous Fruitland Formation coals. A lengthy process of pre-hearing meetings, as well as the actual COGCC formal hearings on this application, characterized the controversies associated with granting permission to drill so many wells with just one application. In the end, the Commissioners for the COGCC approved the application with certain environmental provisions recommended by the staff and by the La Plata County citizens.

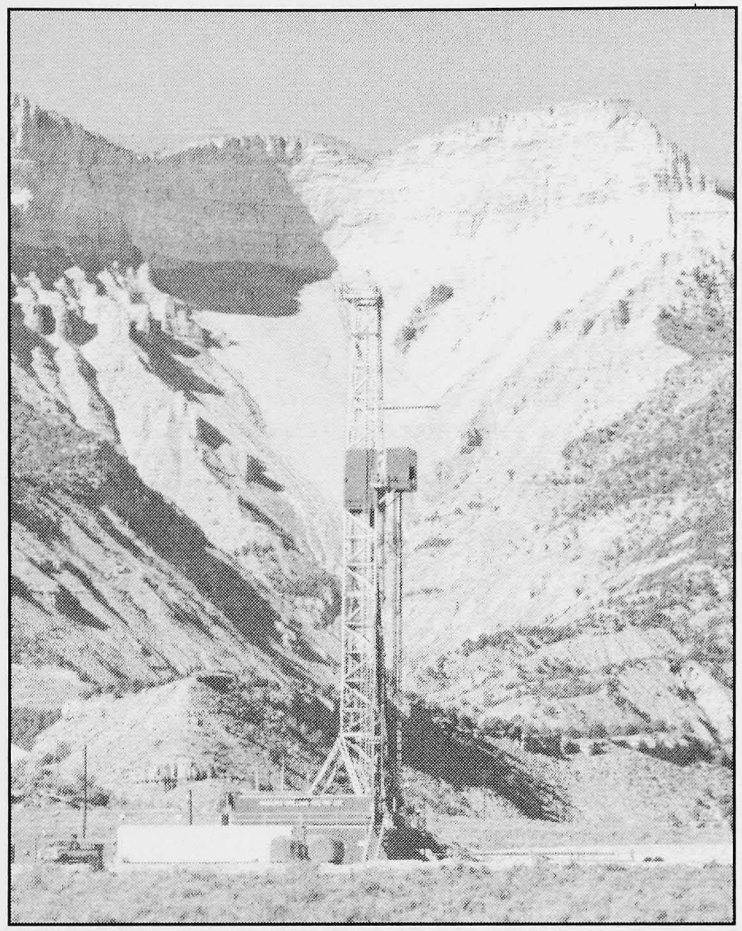

Figure 18. Drilling rig in the Piceance Basin (photograph courtesy of Dennis Henry, Digital MediaVision).

In Garfield County, Barrett Resources filed an application for 20-acre spacing in selected areas of the Piceance Basin for the Cretaceous Mesaverde Group sands (Figure 18).

As with La Plata County, local opposition ran high and the hearings were every bit as contentious. Unlike the San Juan Basin application, however, the Commissioners did not approve blanket infill approval and denied Barrett permission to drill infill wells on approximately 1400 acres in the Rulison South field. In addition, Barrett was challenged to employ horizontal drilling techniques to minimize the surface impact of so many vertical wells. Both applications were predicated on efficient resource recovery and were driven, to a large degree, by high gas prices. Geologic and engineering testimony in both cases demonstrated clearly that the existing network of gas wells was not draining the gas reservoirs in a thorough or efficient manner. Despite the dream that reserves should be left in the ground for future generations, the geologic, engineering, and economic facts suggest that cessation of gas recoveries through existing wellbores will result in abundant gas reserves being left in the reservoirs. These reserves may never be recoverable both technically and economically, barring a phenomenally huge spike in gas prices.

Mergers And Acquisitions

Merger-mania of the mega-companies that began in 1998 has continued today:

BP-Amoco, Exxon-Mobil, then BP-Amoco-Arco (now just plain bp), and most recently (and still unapproved officially as of the time of this writing), Chevron-Texaco or Texaco-Chevron. The latter merger in process will result in the closure of Texaco's Denver office later this year, signaling the last major petroleum company to leave Denver. Only one major company, Phillips, opened a new office in Denver during 2000.

The shape of the industry in Colorado has been adjusting to the steady departures of the larger companies; now, the remaining exploration and development efforts in Colorado is now mostly in the hands of mid-sized and small independents. Like the majors, these companies have engaged in mergers and acquisitions in order to maintain their competitive edge and grow their resource bases. Table 8 attests to this fact.

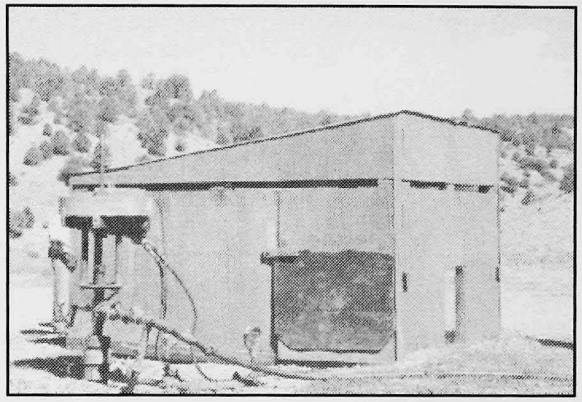

Figure 19. Vermejo Formation production unit and pump in the Raton Basin, south central Colorado.

The most significant acquisition news affecting a Denver company in 2001 involves Shell Oil's impending take-over efforts of Barrett Resources. As of the time of this writing, it is unclear whether Shell will launch a hostile take-over of Barrett or whether Barrett will find a "white knight" to tender a higher price for its stock than what was originally offer by Shell.

Late news indicates that Hallwood Energy has accepted a take-over bid by Pure Oil of Midland, Texas. It is reasonable to expect that the trend of merger and acquisitions will continue.

New Technology and Infrastructure Projects

With higher commodity prices comes the impetus to undertake costly exploration and infrastructure projects. Several such projects were initiated and/or conceived in 2000. Aspect Resources LLC shot approximately 53 square miles of 3D seismic in Rio Grande County over the San Juan Sag for about $1.8 million. The objective was to identify structural targets for Cretaceous Dakota Sandstone and ancillary reservoirs in what could be a northeast extension of the San Juan Basin.

Lexam Exploration, Inc. had planned to drill up to three 11,000-foot gas wells on the Baca Ranch in Saguache County in 2001. Recent developments suggest that this proposed drilling will be delayed for an undetermined length of time.

Responding to the expected increase in gas production, Colorado Interstate Gas plans to build a $160 million

Table 8. Mergers and acquisitions affecting Colorado companies in 2000.

Companies Involved M=merger, A= acquisition	Price Tag ($ million)	Strategy
Anadarko–Union Pacific (M)	$4,400	Stay competitive; diversify holdings
Texaco–Enervest (A)	$121	Acquire underdeveloped CBM properties
Evergreen–KLT Company	?	Expand Raton Basin CBM operations. (See Figure 19)
Forest Oil–Forecenergy (M)	$675	Becomes 10th largest independent producer
USX/Marathon–Pennaco(A)	$ 500	Acquire CBM properties in Powder River Basin
El Paso Energy–Coastal Corp. (M)	$ 2,400	Becomes energy giant operating largest natural gas pipeline
Devon–PennzEnergy Co. (A)	$2,600	Becomes one of top 10 U.S. independents
Devon–Santa Fe Snyder (A)	?	Becomes one of top 5 U.S. independents

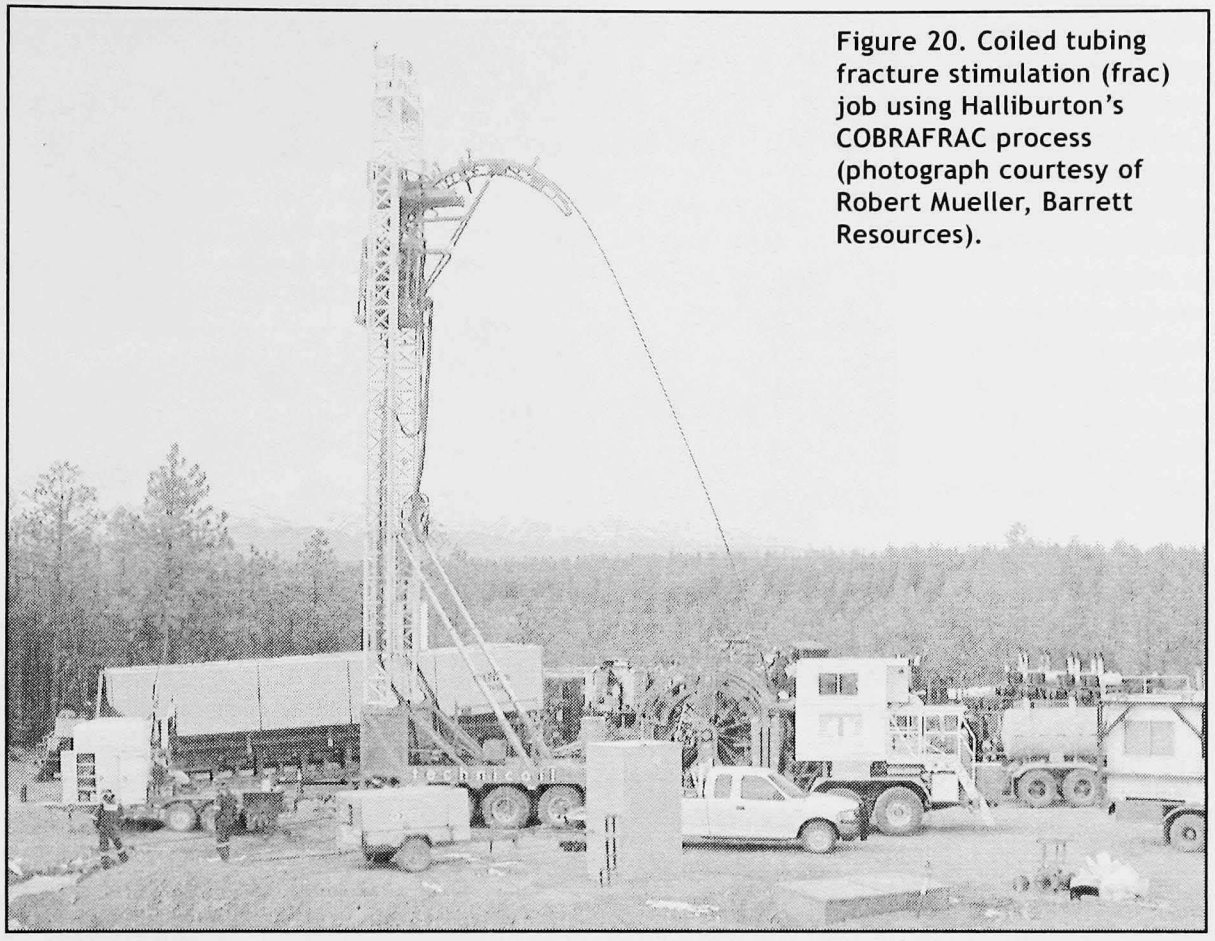

Figure 20. Coiled tubing fracture stimulation (frac) job using Halliburton's COBRAFRAC process (photograph courtesy of Robert Mueller, Barrett Resources).

pipeline from Wyoming through Colorado to other states. The proposed Valley Line Expansion facilities in Colorado include 35.1 miles of 24-inch line and 84 miles of 22-inch line to connect to two existing compressor stations in Ft. Lupton and Watkins in Weld and Adams Counties respectively.

Technologies for drilling and completing coalbed methane wells are steadily improving. Barrett Resources has used Halliburton's COBRAFRAC process to fracture stimulate (frac) wells down coiled tubing (Figure 20). This technology has been used more widely for completing in shallow, thin sands and coals. The coiled tubing-conveyed fracs deliver smaller volumes of proppant and frac fluids, but can achieve economic efficiency by allowing more individual zones to be completed separately in one day. This technique has replaced, in many cases, the practice of perforating thin, stacked reservoirs and then fracing the entire sequence at one time. Large interval fracs have been shown to be ineffective for stimulating all the hydrocarbon-bearing reservoirs, whereas the coiled tubing fracs seem to do a better job of that.

Forecasts

Recognizing that forecasts are fraught with unknowns, it is possible to draw some inferences from the year 2000. A number of factors related to hydrocarbon supply and demand drive the economic fluctuations that are also impacted by climate, technology, and political events. The industry stage has been set to define the possible range of developments that could occur in the next few years. OPEC enacted at least four supply and price adjustments in 2000, signaling its intention to prevent, to the extent possible, wild fluctuations in price in 2001. Industry experts predict crude oil prices to hover near $25 per barrel and natural gas prices to stabilize around $5 per MCF. Political unrest anywhere in the world could upset that formula as could an unusually hot summer or cold winter.

Industrial and commercial gas usage in Colorado, as well as demand for electricity, continues to grow, particularly given the state's continued strong economy. Record cold temperatures in

November and December drove up the demand for heating fuels. Despite this seasonal aberration, a host of energy industries have been predicting a growing demand for electricity in the state and across the nation. According to the Colorado Oil and Gas Association (COGA), over 2000 megawatts of gas-fired power generation (or approximately 200 utility plants nationwide) are scheduled to come on-line by the end of 2003. These electric facilities will require over 17 MMCF of natural gas per hour during peak demand periods. Annual gas demand for generating electricity could increase by 40 to 80 BCF per year (*COGA Flowline*, Sept./Oct., 2000, vol. 16, no. 4. p. 16). Interestingly, of the 250,000 megawatts of proposed additions to electrical generation in the U.S., over 95 percent of them are fueled by natural gas. This signals clearly the dependence on adequate supplies of natural gas, much of which can be derived from Colorado reservoirs. In the year 2001 and beyond, we can expect a resurgence in new infrastructure projects to meet the booming demands for natural gas (Figure 21).

In 2001, Colorado will witness a continued surge in natural gas drilling. Already, record-breaking sales of gas and oil leases on state- and federally owned land in Colorado have driven lease prices from the base rent of $1.50 per acre per year to above $300 an acre for prospective leases. This does not necessarily imply that the overall supply of gas and oil will increase or even remain level. Gas well declines are becoming steeper as increased drilling is depleting the reservoirs at a more rapid pace. Drilling for crude oil reserves in Colorado may increase, driven by high, stable prices, but unless new oil reservoirs are discovered, the continual decline in production is expected in 2001. The Bush administration's focus on increased domestic petroleum activity, coupled with high oil prices, should insure that the level of oil drilling remains vibrant into 2001.

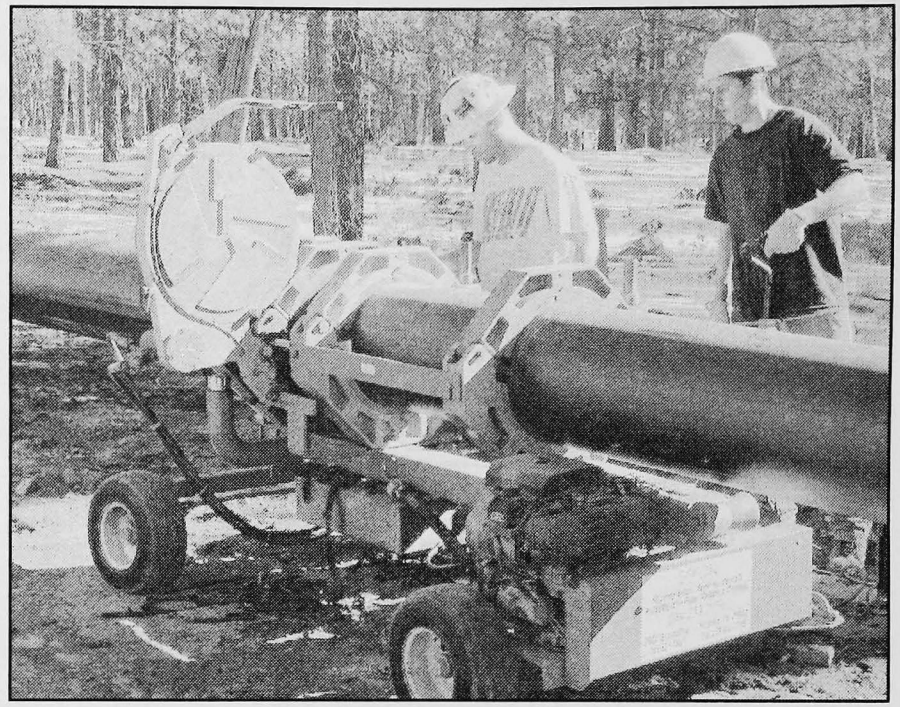

Figure 21. Fusing 16-inch poly pipe for a new, low-pressure gathering trunk line, Raton Basin, south central Colorado (photograph courtesy of Robert Mueller, Barrett Resources).

Given the recent electricity woes in California, we can expect a business emphasis on longer-term gas contracts and increased focus on stable energy prices. Whether or not the latter can be achieved successfully remains to be seen. Given the high heating prices of the 2000–2001 winter season, however, it seems likely that conservation measures will be the rallying cry of the public. How these measures will be implemented, regulated, or funded through monetary incentives are still unclear. Therefore, it follows that until alternative energy sources become competitive and abundant, pipeline capacity will have to be increased to meet growing demands, more stable prices, and the need to replace gas reserves taken from storage in late 2000. In summary, we can expect a full range of activities related to energy supply from fossil fuels in the year 2001.

Coal

Introduction

Colorado's coal market outlook remains positive even though production was slightly less in 2000 than the previous year. On the heels of record-breaking production in 1999, coal production was slowed in February by a mine fire at the state's second largest mine, the West Elk Mine. The largest coal lease sales in history occurred in May as both Bowie Mining and Oxbow Mining increased their reserves substantially. Many long-term contracts expired with the millennium, and coal production was merely level throughout the summer. In the fall, the coal market heated up. An increase in both contract and mine-mouth prices enabled the coal companies to increase production by year's end. Year-to-date coal production as of March 2001 was 28 percent higher than for the same period in 2000 [Energy Information Agency (EIA) rail car loadings data, March 2001]. The spot market price of Colorado coal today is roughly $15 per ton.

Energy consumption is high. A potentially severe energy crisis threatens California this summer, and along with very high natural gas prices over the past winter, the outlook of coal as a cheap source of power is enhanced. At current pricing, coal power is about one-fifth the cost of natural gas (*Paydirt*, February 2001). Looming national environmental compliance deadlines (2004) should increase the need for more clean Colorado coal throughout the country. Costs for air-pollution control equipment for mercury emissions will make the price of coal-generated power more expensive. Energy strategies for the U.S. must focus on the expansion of domestic supplies including coal.

Colorado is the tenth leading coal producing state in the nation (EIA data, Feb. 2001), and with coal production in North Dakota and Indiana on the decline in 2001, Colorado is on pace to be ranked eighth in the nation this year. For the first time in four years, the state's total coal production decreased over the previous year. The number of miners increased slightly, but the number of mines decreased as the Southfield Mine near Florence closed its doors on January 1, 2001.

Coal Production in 2000

Colorado coal companies produced 29,162,692 tons of coal in 2000 (Table 9). Coal was supplied from 12 mines, 8 underground and 4 surface operations (Figure 22). October was the most productive month with 2,860,076 tons produced from all mines. Coal was produced from nine of Colorado's 63 counties in 2000-Delta, Fremont, Garfield, Gunnison, La Plata, Moffat, Montrose, Rio Blanco, and Routt (Figure 23). The three largest producing mines were Foidel Creek (7.22 million tons), Colowyo (5.17 million tons), and Bowie No. 2 (5.03 million tons). These three mines combined produced 16.8 million short tons of coal, or 59 percent of the state total. Foidel Creek, Bowie No. 2, and the West Elk Mines are three of the largest underground mines in the west. More coal was produced in Routt County (30 percent of the state total) than any other with over 8.78 million tons of coal from both the RAG-Twentymile Coal Co.'s Foidel Creek underground mine, and Peabody's Seneca II-W and Yoast surface mines near Hayden. Colorado is on track to break the 30 million-ton barrier. Since 1991, Colorado coal production has increased from 17.7 million tons to 30 million tons in eight years (Figure 24).

In 2000, most of Colorado's coal was produced in the Uinta Coal Region, which extends from Moffat County (Colowyo Mine) to Gunnison County (West Elk Mine). Nearly 17.57 million tons of coal was produced in the Uinta Coal Region, an increase of three percent over 1999 (Table 9). Historically, the Uinta and Green River coal regions have each produced more than 300 million tons of coal (1864–2000).

Economic Impact

According to the Colorado Division of Minerals and Geology, Colorado's coal mines employed 1,690 miners in 2000, an increase of 31 miners or 2 percent higher than the 1999 level. This number includes both miners and surface support staff, but not administrative and supervisory personnel. Figure 24 is a

Table 9. 2000 Colorado coal mining statistics. See Figure 22 for mine locations (data from Colorado Division of Minerals and Geology).

Mine No.	Mine Name	County	Coal Region	Coal Field	Operator	Twp., Rge.	Geologic Formation	Producing Bed Names	Seam Thickness (ft)	Btu Avg.	Mine Type	Mining Method	2000 Prod. (tons)	Dec 2000 Miners	Shipment Method
1	**Bowie No. 2**	Delta	Uinta	Somerset	Bowie Resources Ltd.	13S, 91W	Mesaverde	D	9–12	11,800	U	Longwall Continuous	5,034,046	181	Truck, rail
2	**Southfield**	Fremont	Canon City	Canon City	Energy Fuels Coal, Inc.	20S, 69W	Vermejo	Red Arrow	5.5	11,050	U	Continuous	197,490	27	Truck
3	**West Elk**	Gunnison	Uinta	Somerset	Arch (ACI) Mountain Coal Co.	13S, 90W	Mesaverde	B	14	11,650	U	Longwall, continuous	3,369,242	297	Rail
4	**Sanborn Creek**	Gunnison	Uinta	Somerset	Oxbow Carbon & Minerals, Inc. (Pacific Basin Resources)	13S, 90W	Mesaverde	B, C	18, 6–8	12,375	U	Longwall, continuous	2,156,671	211	Rail
5	**King Coal**	La Plata	San Juan River	Durango	National King Coal, LLC	35N, 11W	Upper Menefee	Upper bed	4.3–6	12,800	U	Continuous	192,893	29	Truck
6	**McClane Canyon**	Garfield	Uinta	Book Cliffs	Lodestar	7S, 102W	Mesaverde	Cameo B	4.4–9.4	11,250	U	Continuous	305,343	18	Truck
7	**Colowyo**	Moffat	Uinta	Danforth Hills	Colowyo Coal Co. (Kennecott)	4N, 93W	Williams Fork	A-F, X,Y	8 beds–5.4–10.7	10,453	S	Dragline, shovels, dozers	5,171,221	260	Rail
8	**Trapper**	Moffat	Green River	Yampa	Trapper Mining, Inc.	6N, 90W	Mesaverde	H,I,L Q,R	6, 5, 4 13, 4	9,850	S	Dragline, dozers, hyd. excav.	2,059,156	109	Truck
9	**New Horizon**	Montrose	San Juan River	Nucla-Naturita	Western Fuels Assn.	46N, 15W	Dakota	1,2	0.75–1.25, 4.0–6.5	10,800	S	Shovels, dozers	364,759	25	Truck
10	**Deserado**	Rio Blanco	Uinta	Lower White River	Blue Mountain Energy, Inc.	3N, 101W	Williams Fork	B seam	7–16	10,000	U	Longwall, continuous	1,529,940	138	Rail
11	**Twentymile (Foidel Creek)**	Routt	Green River	Yampa	Twentymile Coal Co. (RAG American Coal)	5N, 86W	Mesaverde	Wadge	7–11	11,250	U	Longwall, continuous	7,221,703	308	Rail
12	**Seneca II-W, Yoast**	Routt	Green River	Yampa	Peabody Western . Coal Co	5N, 87W	Lower Williams Fork	Wadge, Wolf Cr., Sage Cr.	8.9–14.2, 15–20.4, 3.4–5.4	11,908–12,581	S	Dragline, loaders	1,560,228	87	Truck, rail
Total													**29,162,692**	**1,690**	

Abbreviations: Mine Type: **U**—underground; **S**—surface

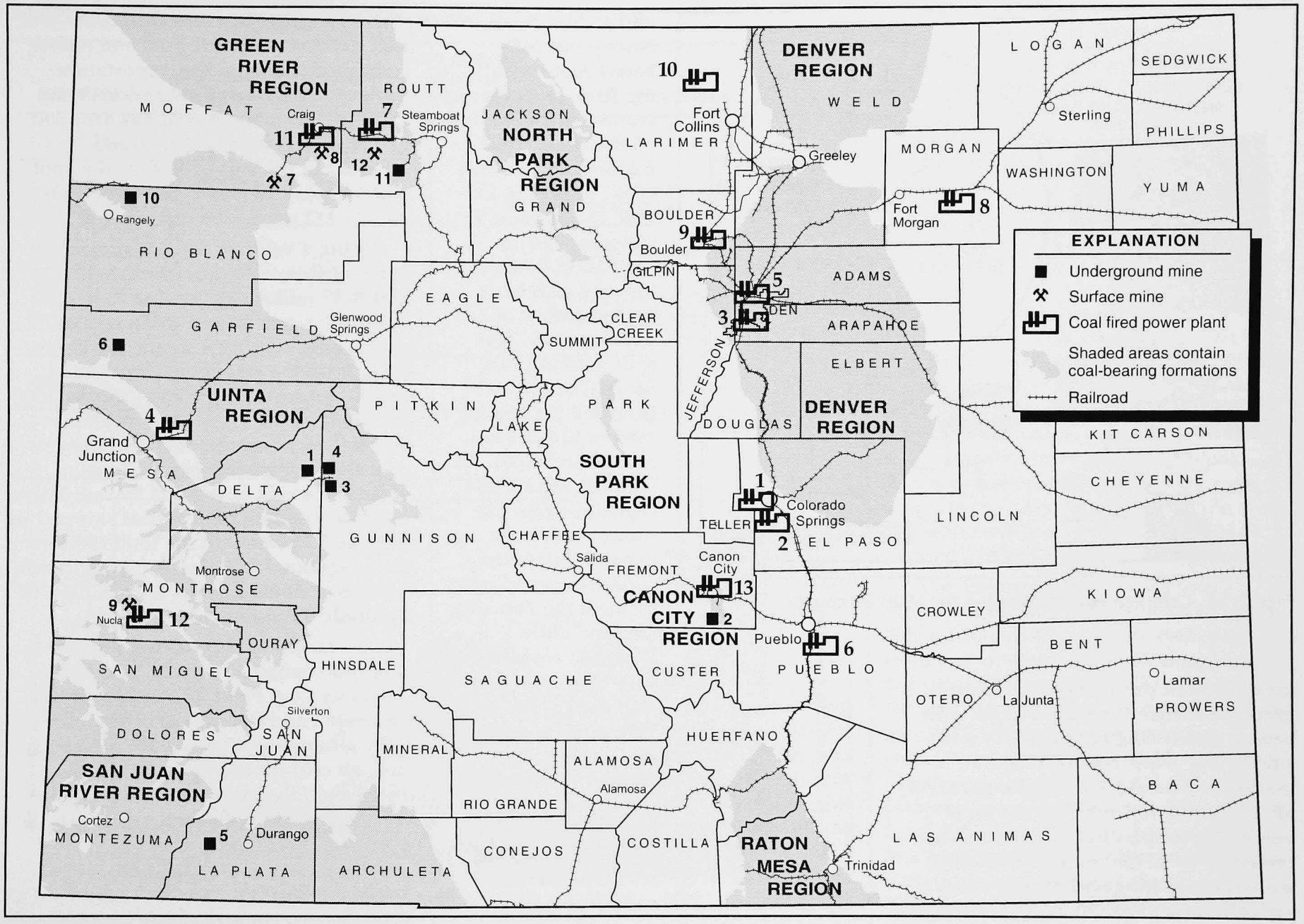

Figure 22. Map of Colorado coal mines and power plants. See Table 9 for mines and Table 13 for plants.

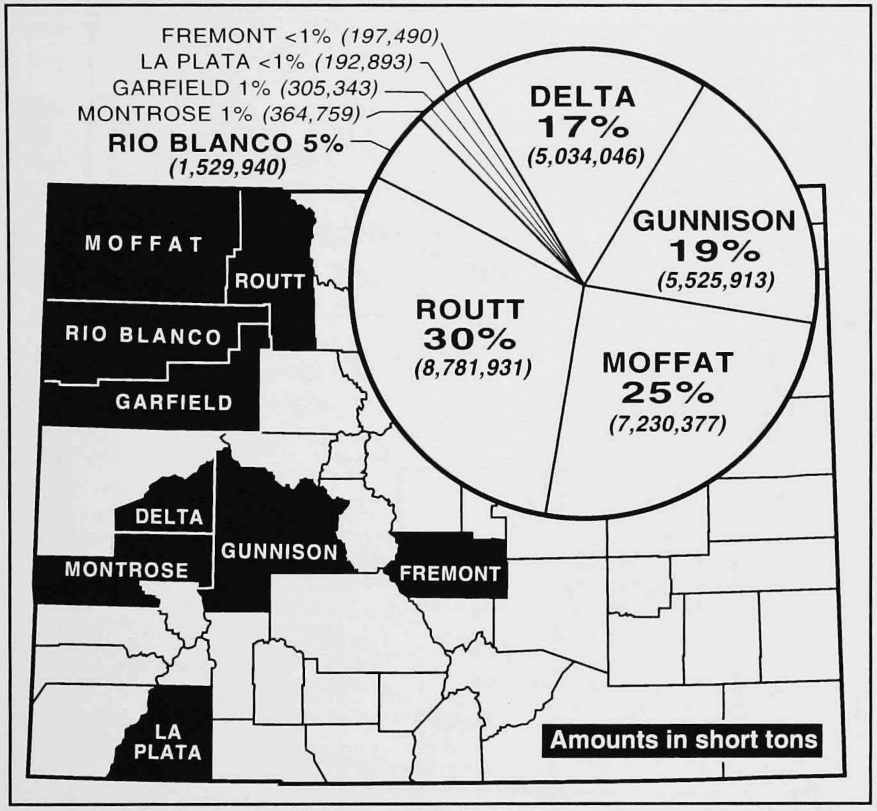

Figure 23. Colorado coal production for 2000 by county.

graph of coal production and miners employed since 1960. This trend indicates a decreasing employment rate since 1978, while coal production increased markedly. Employment is relatively stable for only the last three years. The graph illustrates increasing productivity at Colorado mines since the advent of longwall mining machinery and large capacity machinery at surface mines.

Hill & Associates, an Annapolis, MD-based coal consulting firm, recently studied and evaluated the future coal markets for western coal. According to Hill, the outlook for Colorado coal is very good. Most of the coal mines currently operate at or near capacity. The spot market price for coal has risen from $12 per ton in 1999 to $16 per ton as of March 2001. To increase production capacity, Colorado mines must now expand. Increased capacity should easily meet the demand for good clean Colorado coal. In the long-term, Hill suggests Colorado has abundant reserves of low-sulfur coal that will sustain current and expanded production levels well into the future. The industry will transition more to deep mines, but mining conditions in both the Green River and Uinta regions of northwestern Colorado are expected to be favorable and costs should be low. Colorado prices have recently increased as a result of low inventories, greater demand from Midwest power producers, and short-term production and transportation problems. Between 1989 and 1999 the mine-mouth price of coal has dropped 57 percent nationally. This trend reversed at the end of 2000 as the spot market price increased from approximately $12 per ton to $15 per ton.

Using a value of $15 per ton, the value of Colorado coal produced in 2000 was $437 million. According to the *Denver Business Journal* (March 9, 2001), coal is now making a significant comeback. With the recent quadrupling of natural gas prices between October 2000 and January 2001, coal has suddenly become the economic fuel of choice for co-generation power plants. Most of Colorado's coal is shipped by rail. There were 24.2 million tons of coal shipped in 1999, or 73 percent of the total rail tons that originated in Colorado. Freight railroads contributed about $192 million to Colorado's economy during 1999.

The largest BLM coal lease sale in Colorado occurred in May 2000 in the Somerset Coal Field. It is expected that the State Land Board will collect more than $44 million in royalties and bonuses from coal production of the Iron Point and Elk Creek tract lease sale in the North Fork Valley over the next 8 years.

Coal Quality

Coal-bearing units underlie some 29,600 square miles or 28 percent of Colorado.

Table 10. Colorado coal production for 2000 by coal region.

Coal Region	Production (tons???)	No. of Miners	No of Mines (Surface/ Underground	Mine Names
Canon City	197,490	27	0/1	Southfield
Green River	10,841,087	504	2/1	Foidel Creek, Seneca (Seneca II-W and Yoast), Trapper
San Juan River	557,652	54	1/1	King Coal, New Horizon
Uinta	17,566,463	1,105	1/5	McClane Canyon, Deserado, Sanborn Creek,West Elk, Bowie No, 2, Colowyo
Total	**29,162,692**	**1,690**	**4/8**	

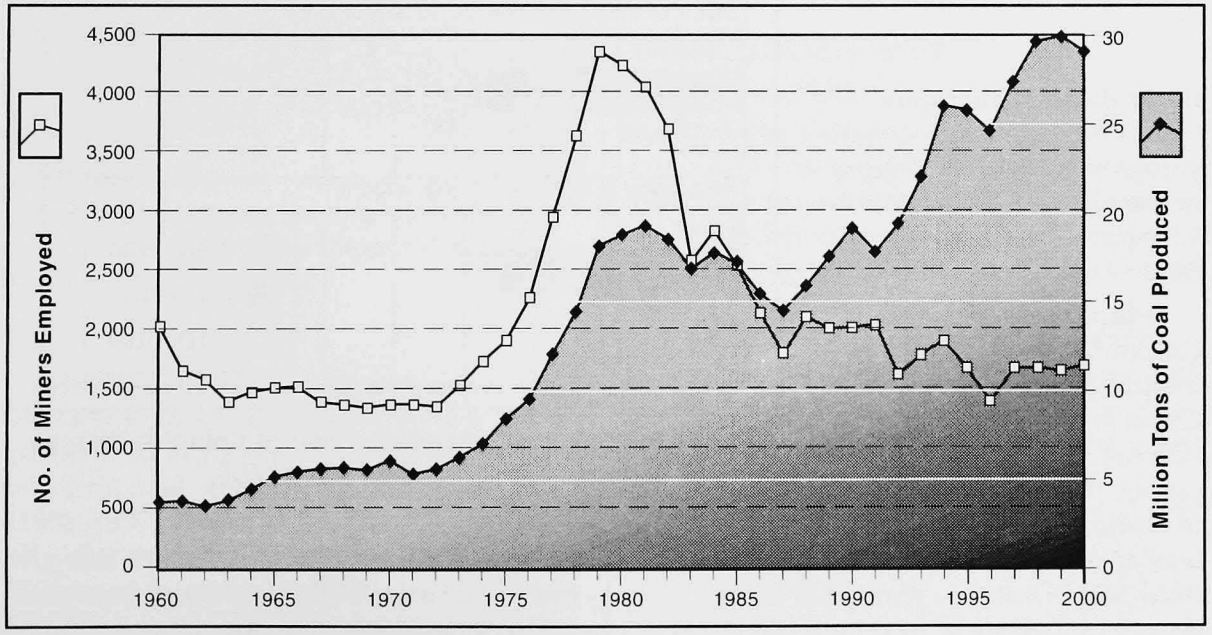

Figure 24. Coal production and miners employed in Colorado, 1960-2000.

According to a recent U.S. Geological Survey (USGS) report on coal resources of the Colorado Plateau (Professional Paper 1625-B), in-place Colorado coals range from 9,700 Btu (Danforth Hills field) to 14,200 Btu (Carbondale field) heat values (Figure 25). With sulfur ranging from 0.42 percent (Danforth Hills field) to 0.95 percent (Durango field), and ash ranging from 5.1 percent (Crested Butte field) to 18 percent (Durango field), Colorado coals are among the highest quality, cleanest fuels found anywhere in the world. Most of this coal is clean enough to burn without washing or further preparation. Coal mined in Colorado today is mostly bituminous coal, low in sulfur content and trace elements (mercury and arsenic), and generally moderately low ash content. Due to these factors, Colorado coal is used extensively as blended compliance coal in power plants in other states.

The Environmental Protection Agency (EPA) recently decided to establish guidelines for mercury emissions from power plants by 2004. Coal-burning power plants emit more mercury to the air than any other source. According to a 1997 EPA study, these utilities contribute between 40 and 52 tons annually or one-third of the total U.S. anthropogenic mercury emissions. Mercury can bioaccumulate in fish and animal tissue in a highly toxic form called methylmercury. However, USGS Professional Paper 1625-B concludes that mercury content in Colorado coal is among the lowest in

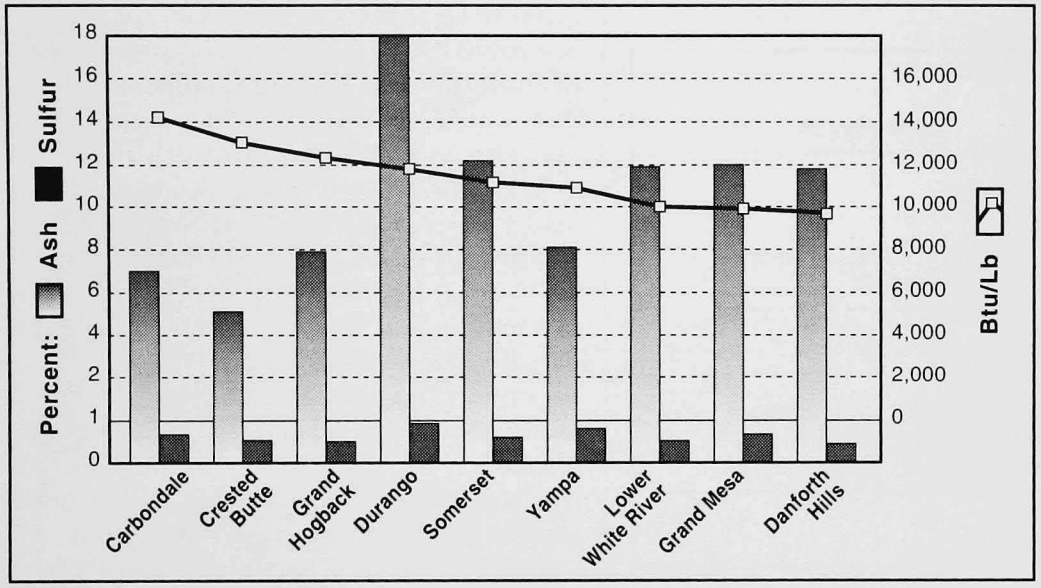

Figure 25. Ash, Btu, and sulfur analyses of Colorado coal fields. Data from USGS *Colorado Plateau Coal Assessment*, Professional Paper 1625-B, 2000.

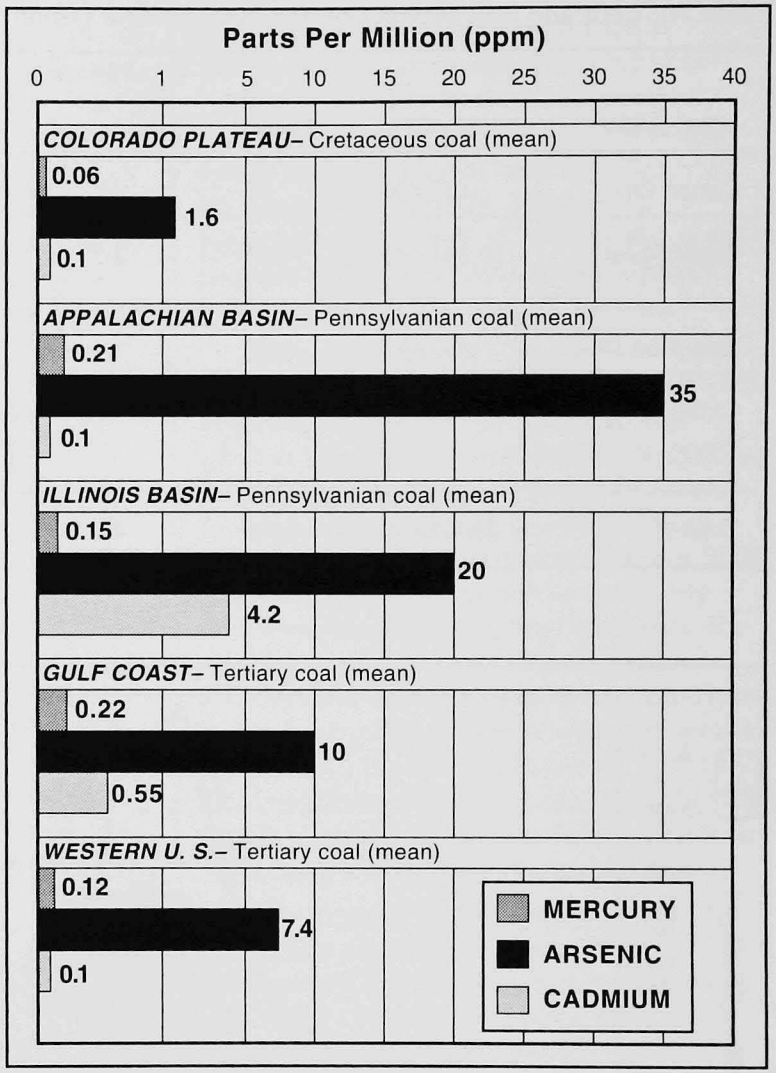

Figure 26. Trace element comparison of Colorado Plateau coal to other major coal regions of the U.S.

the nation (Figure 26). Mercury varies from 0.04 ppm in the Lower White River and Grand Hogback fields to 0.08 ppm in Durango field. In comparison to other coal regions of the U.S., the Cretaceous-age coals (Figure 27) in the west average much lower trace elements of environmental significance. Mercury averages 0.06 ppm in the Colorado Plateau while eastern Pennsylvanian-age coals range from 0.15 to 0.21 ppm, and 0.12 to 0.22 ppm for Tertiary-age coals of the Gulf Coast and Powder River Basin. Similarly, arsenic in the Colorado Plateau averages 1.6 ppm while Appalachian coals range from 20 to 35 ppm, and Gulf Coast and Powder River Basin coals range from 7.4 to 10 ppm. Arsenic values vary from 0.39 ppm in the Crested Butte field to 4.8 ppm in the Durango field.

Future use of clean Colorado coal for environmental compliance with the Clean Air Act Amendment (CAAA, 1990) is assured at power plants for some time to come. The Amendment was aimed at reducing acid rain by limiting SO_2 emissions from coal fired power plants, most of which are in the eastern U.S. Those plants may switch fuels to lower-sulfur coal, install flue gas desulfurization (scrubbers) equipment, or purchase additional emission allowances. According to a recent report

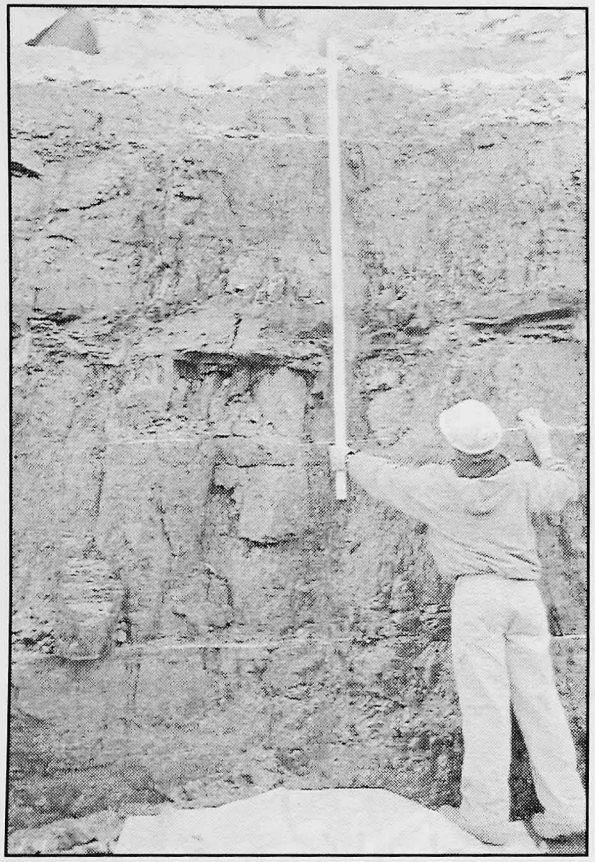

Figure 27. Trapper Mine employee measuring a coal seam from the Upper Cretaceous Williams Fork Formation

by the EIA, more than 50 percent of the affected plants chose to switch to a lower-sulfur coal or increased usage of blended clean coal. Over the ten year study (1988-1997) EIA concluded that, nationally, the average sulfur content of coal delivered to electric utilities has declined by 13 percent, from 1.26 lbs. of sulfur to 1.09 lbs. of sulfur per million Btu.

On March 14, 2001, President George W. Bush decided against implementing new air pollution controls on the nation's power plants regarding CO_2 emissions. Bush said he supports a "comprehensive and balanced energy policy that takes into account the importance of improving air quality." However, he cited an Energy Department study in December that reported regulating carbon dioxide would lead to higher electricity prices, particularly in the hard-hit West. He added that new air pollution controls would "lead to an even more dramatic shift from coal to natural gas for electric power generation and significantly higher electricity prices compared to scenarios in which only sulfur dioxide and nitrogen oxides were reduced."

Distribution and Consumption

In 2000, the Colorado Geological Survey compiled coal production and distribution data from both the active coal mines and the Colorado Division of Minerals and Geology (CDMG). According to that data, of the 30 million tons of coal produced in 1999, nearly 17.3 million tons of coal were exported to other states and foreign countries, and nearly 12.7 million tons were shipped to locations within the state (Figure 28). The largest domestic recipients of Colorado coal are Kentucky, Tennessee, Texas, Missouri, Utah, and Mississippi; each receiving between 1 and 3 million tons of coal. Most Colorado coal (93 percent) is used as steam coal domestically in the U.S. Colorado also exported 1.82 million tons of coal to Japan.

Wyoming coal is shipped through Colorado as well. Approximately 30 million tons of subbituminous and lignite coal is shipped from Wyoming to Texas, much of which passes through railroads in Colorado. Colorado imports approximately 7.9 million tons of Powder River Basin coal for use at several power plants along the Front Range (Table 11). Overall, the amount of coal delivered to power plants has increased by 20 percent between 1988 and 1997. This was accompanied by a shift in coal source as most of the coal nationally comes from low-sulfur subbituminous coal in the Powder River Basin.

Colorado electricity generation increased 2.3 percent, but most of this was due to increased usage of natural gas and oil. Coal consumption was

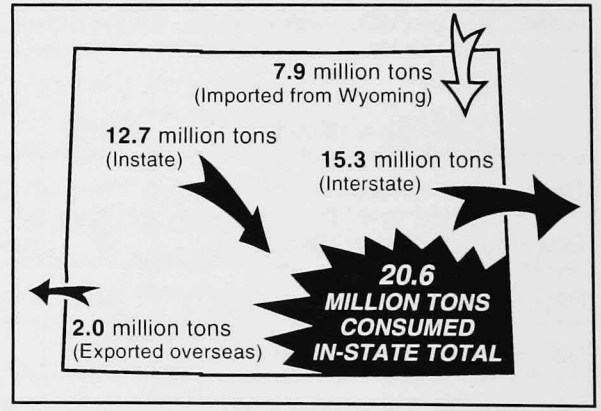

Figure 28. 2000 Colorado coal consumption diagram.

Table 11. Distribution statistics of coal produced in Colorado, 1999 (EIA data).

County	Mine	Tons Shipped (x1000)			Total Production (tons x 1000)
		In-State	Out-of-State	Out-of-Country	
Delta	Bowie No. 2	175	1,573	0	1,748
Fremont	Southfield	216	27	0	242
Gunnison	Sanborn Creek	0	962	0	962
West Elk	1,419	4,966	709	7,095	
La Plata	King Coal	25	194	27	246
Mesa	Roadside	285	0	0	285
Moffat	Colowyo	3,620	1,949	0	5,569
Trapper	2,219	0	0	2,219	
Montrose	New Horizon	359	0	0	359
Rio Blanco	Deserado	0	1,337	0	1,337
Routt	Seneca II	8	0	0	8
	Seneca II-W	685	0	0	685
	Yoast	670	0	0	670
	Foidel Creek	2,995	4,278	1,283	8,556
Total		**12,675***	**15,287***	**2,020***	**29,981**

* Rounded to nearest 1,000

down by 4.7 percent. Hydroelectric power, biomass and wind energy is also generated in the state. No nuclear energy is produced in Colorado.

According to EIA, Powder River Basin coal increased its share of coal sales in the east, capturing 35 percent of the national market today. Over the same period, Colorado doubled its coal production, but only increased its sales to 5 percent of the national market share.

Productivity and Capacity

A total of six longwall operations were counted in Coal Age magazine's annual Longwall Census 2001 (February 2001) in Colorado. Five are operational and one is idle. The longwall at the Foidel Creek (Twentymile) Mine in Routt County is the most productive in the state. Longwall machinery at Foidel Creek, Bowie No. 2, and Deserado mines were working at or near capacity

Table 12. Colorado underground longwall mining statistics, 2000 (source: *Coal Age*, February 2001).

Company (Mine)	Seam	Seam Height (in.)	Cutting Height (ft)	Panel Width (ft)	Panel Length (ft)	Overburden Thickness (ft)	Depth of Cut (in.)	Shearer
Bowie Resources (Bowie Mine No. 2)	D	108–180	120	845	7,000	800–1,400	36	Long-Airdox DDR EL 1,300
Blue Mountain Energy (Deserado)	B	84–180	132	800	6,000	240–1,800	32	Joy 4LS DDR 1,030
RAG American Coal (Empire), idle	E	126–138	120	750	7,500	600–1,200	36	Long-Airdox DDR 1,200
Oxbow Mining (Sanborn Creek)	B	180	132	450	3,700	1,500–2,500	30	Joy 4LS DDR 1,030
RAG American Coal (Foidel Creek)	Wadge	96–114	96–114	1,000	12,000–15,000	600–1,400	36	Long-Airdox DDR 1,920
Arch-Mountain Coal Co. (West Elk)	B	276	144	950	3,500–9,000	600–1,400	40	Joy 6LS-2 DDR 1,720

in 2000. The Empire Mine longwall has been idle since 1995. The longwall systems operating in Colorado last year had panel widths ranging from 450 to 1,000 feet, panel lengths ranging from 3,700 to 15,000 feet, and cutting heights ranging from 96 to 144 inches (Table 12).

West Elk's longwall machine was idled for four months due to a mine fire. They had a thermal event that closed the mine for four months in early 2000, but the mine is back to full capacity in 2001. The event was extinguished by flooding the suspected fire area with water. According to Mine Safety and Health Administraton (MSHA), this mine fire recovery is considered the most successful remote sealing and flooding project in the U.S. to date.

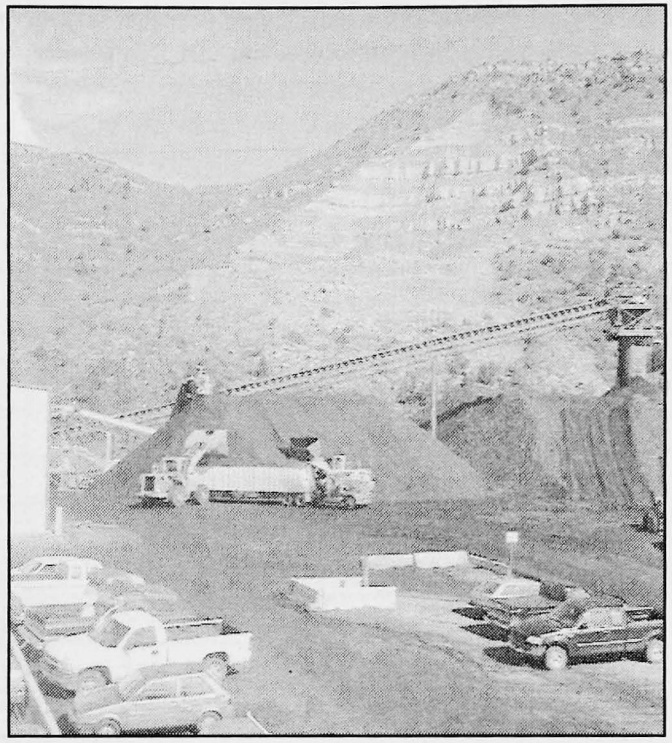

Figure 29. Bowie Mine No. 2.

News and Developments

A favorable ruling for the Colorado coal industry was issued in March 2000. The nearly two-year Environmental Impact Study (EIS) on coal resources implemented by the U.S. Forest Service and the Bureau of Land Management (BLM) in the North Fork Valley of Gunnison County was finalized and approved for leasing. The BLM lease sale was held in May 2000 as Bowie Resources and Oxbow Mining received new leases north of their respective current mining plans. Both mines will generate a combined $880 million in revenues from the sale of the coal over the next ten to fifteen years. A combined 54 million tons of coal were leased for production between the Iron Point (Bowie No. 2 Mine) and Elk Creek (Sanborn Creek Mine) tracts. Bowie Resources bid $10.3 million for 3,211 acres of coal with a reserve estimate of 32.6 million tons. Oxbow bid $8.7 million for 4,444 acres of coal with a reserve estimate of 20.9 million tons.

To keep pace, Bowie Mine No. 2 reached its production goal of 5 million tons in 2000, up from its 1.7 million in 1999. This 188 percent increase in coal production made Bowie the third leading coal producer in the state (Figure 29). They are currently exploring and mining in part of the new lease area. To meet this demand, Bowie constructed an efficient downhill conveyor system last year. They also plan to build a unit train loadout at the bottom of the hill. Bowie may also buy an in-mine Hagby drill to explore the B seam beneath the operating D seam.

A coal-bed methane work group organized by the BLM has nominated leases on Bowie property and vicinity as part of a new coalbed methane exploration target. The BLM hopes to join partners between the coal miners and methane gas groups in that area. Oxbow Mining has been having high levels of methane in their new longwall panels. They are mining at depths in excess of 2,000 on the east side of the mine with poor roof conditions and methane levels that now require a series of degasification wells for safe mining. Sanborn Creek has now installed the first of ten planned wells this year and this has already improved mining conditions. West Elk Mine also plans to install degasification wells in the near future.

California's energy crisis is marked by electricity shortages brought on by significant price increases for natural gas. Deregulation of the electric utility industry is a large factor in California's

energy crisis. Increased demand for electricity combined with the failure to site new baseload power plants over the last 20 years are also major contributors to the problem. California's plants can't meet the demand for the state's power demands, and on peak power days must purchase 25 percent of its power from other states. Their power grid is stressed to the point that rolling blackouts are used to keep the system from failing. High demand, transmission problems, power plants, and a moratorium on coal-fired power plants are partly to blame. California has based its electrical system on an oversupply of natural gas. This crisis has brought a new awareness to the public about coal and other fuels used to create electricity. Hopefully, regulators of power plants in Colorado can learn from the California experience and proceed with deregulation in a more economic manner. In the summer of 2001, much of the west will be in a race for the electrical power switch. Even nuclear power plants saw a national increase in 2000, and pose a small but renewed competition to coal. Energy consumption is way up, and conservation efforts will have to make a strong comeback after a 20 year hiatus.

Another new concern for the coal industry in 2001 is the Roadless Area initiative on U.S. Forest Service property. The rule suggests that nearly one-third of all U.S. Forest Service land be designated unusable for road construction, economic development, and public access. Two mines, West Elk and Sanborn Creek, are affected by the proposed new rule whereby no new roads can be created in designated 'Roadless' areas. These areas impact development plans for both mines, particularly for West Elk. The mines may still operate but no new roads or exploration drilling may be conducted. This rule is scheduled to take effect in May 2001.

Recently, the Colorado Public Utilities Commission forced Xcel Energy, Inc. to include a large wind farm near Lamar, Colorado in its five-year plan. This $160 million wind farm installation is projected to add 1,270 megawatts by the year 2005. Five other natural gas plants are also planned for development. Tri-State Generation and Transmission announced in March 2001 that it is considering building a $1.2 billion coal-fired power plant south of Las Animas. Construction could start by 2003. This would be the first coal-fired power plant constructed in Colorado since 1983. With inflated prices for natural

Table 13. Consumption of coal at electric generation plants in Colorado, 1999. See Figure 22 for plant locations (source: 2001 Keystone Coal Industry Manual).

Map No.	Plant	Utility	Location	1999 Consumption (1,000 tons)
1	Drake	City of Colorado Springs	Colorado Springs	715
2	Nixon	City of Colorado Springs	Fountain	464
3	Arapahoe	Xcel Energy	Denver	789
4	Cameo	Xcel Energy	Palisade	323
5	Cherokee	Xcel Energy	Denver	2,230
6	Comanche	Xcel Energy	Pueblo	2,975
7	Hayden	Xcel Energy	Hayden	1,364
8	Pawnee	Xcel Energy	Brush	2,591
9	Valmont	Xcel Energy	Boulder	340
10	Rawhide	Platte River Power Authority	Wellington	1,264
11	Craig	Tri-State G&T Assn.	Craig	3,932
12	Nucla	Tri-State G&T Assn.	Nucla	319
13	Clark	Utilicorp United, Inc.	Canon City	118
Total				**17,424**

gas, coal has become a cheap, relatively clean fuel supply for electricity generation (Table 13, p. 30). Eighty-one percent of Colorado's electricity comes from coal (Figure 30). Ninety- three percent of Colorado's coal production is used for electrical generation nationally. The other 7 percent are used in industrial and residential applications.

The long-range outlook is not as bright from the smaller coal mines. The Southfield Mine near Canon City closed its doors at the end of 2000. The mine closed because long-term contracts with its customers (Holnam, Inc. cement-plant in Florence, and West-Plains power plant in Canon City) could not be reached. Southfield decided not to expand the mine into new reserves (Figure 31). This closes the book on 120 years of continuously operating coal production from Fremont County.

The Roadside/Cameo Mine in Mesa County closed permanently last winter. Coal supplied to the Cameo Power Plant was replaced by the February 2000 re-opening of the McClane Canyon Mine in Garfield County. This mine produced 305,343 tons in 10 months of operation from the Cameo B seam in the lower Mesaverde Group. McClane has a continuous miner operation that worked around a fault zone with little difficulty last year. McClane expects to proceed at full production for many years to come.

The coal business in southwest Colorado is steady. The state's smallest coal mine, King Coal, announced recently that it would expand its current operations soon. They want to increase their lease holdings to 320-acres, which was recently approved by the CDMG. Their coal is sold to cement processors in New Mexico and Arizona, and about 3,000 tons of stoking coal goes to the Durango & Silverton Narrow Gauge Railroad in Durango. King Coal must truck all of their coal to the markets. The expansion will not increase production, but rather will allow King Coal to maintain its present rate of production at just less than 200,000 tons annually for several more years.

New Horizon Mine in Nucla supplies a small power plant nearby. New

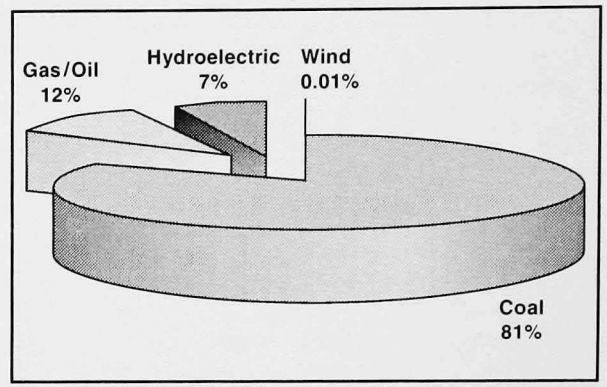

Figure 30. Estimated electricity generation by fuel type at Colorado power plants, 1999.

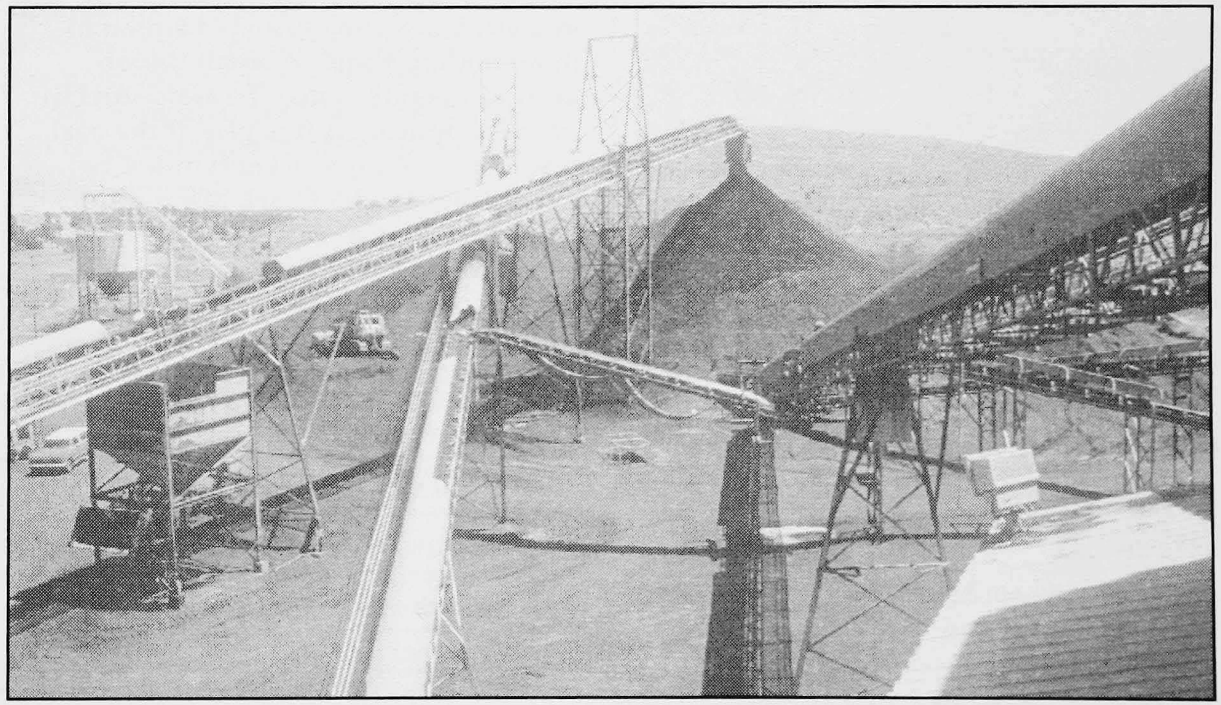

Figure 31. Conveyor belt system at the Southfield Mine.

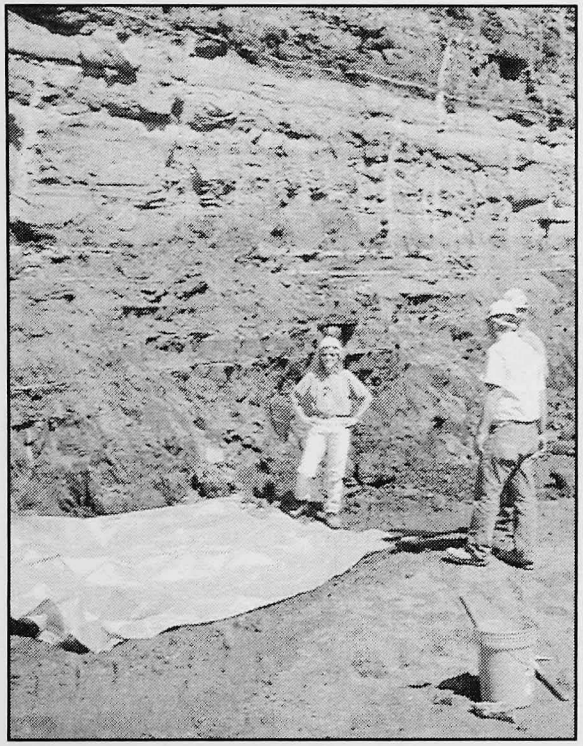

Figure 32. CGS geologist collecting coal samples at the New Horizon Mine.

Horizon won a CDMG reclamation award in 2000 for the best small surface mine reclamation project. They produce coal from a strip on the edge of Nucla. Production at the mine is steady and should supply about 350,000 tons per year from coal in the Dakota Sandstone (Figure 32).

Deserado underground mine in Rio Blanco County has been operating their longwall in the Mesaverde Formation 'B' seam without incident. No major changes to the mine occurred in 2000, other than a longwall move in December. Deserado has the only continuously operating coal preparation plant in the state (Table 14) as they provide the Bonanza power plant in Utah with a low-sulfur, subbituminous 'A' coal. Deserado moved its longwall in December to a second panel in the 'B' seam. It has a higher ash content than the previously mined 'B' seam panel, and the prep plant is used on 50 percent of its coal to premix for Bonanza.

Peabody's Seneca II-W and Yoast mines near Hayden operated continuously in 2000 without problems, supplying the Hayden Power Plant. If the spot market price of coal exceeds $17 per ton in 2001, Seneca may re-visit a plan to mine underground. A small underground operation may be submitted for permit application this year if the coal prices remain high. Twentymile Coal Company's Foidel Creek Mine continued operations in 2000 at a slightly reduced rate from their record-setting year in 1999. They acquired several new contracts in the fall and are operating at record capacity again in 2001.

Nationally, coal production was down by 24 million tons in 1999 due to large stockpiles, low coal prices, and improved nuclear power plants. National coal consumption was down 4 million tons from 1998 to 1999 as well. However, in 2001 U.S. coal production is already up 16 percent for the first three months. In January, an all-time record for one month coal production was set at 101.5 million tons, according to preliminary statistics of the EIA.

Long-term contracts are diminishing industry-wide and Colorado coal producers are facing tough competition from low-cost producers such as the large surface mines in Wyoming, which can economically produce coal in the $5 per ton range. In 1997, the average delivered price for coal from the Powder River Basin was $1.49 per million Btu, and coal from the Rockies region was $1.65 per million Btu.

Table 14. Coal preparation plants in Colorado (source: *2001 Keystone Coal Industry Manual*).

Company	Prep Plant	Location	Raw Feed (tpf)	Year Built
Basin Resources	New Elk	Weston	550	1984
Blue Mountain Energy	Deserado	Rangely	900	1983
RAG American	Foidel Creek	Oak Creek	250	1995
Energy Fuels Coal	Southfield	Florence	240	1979
Oxbow Mining, Inc.	Terror (Sanborn) Creek	Paonia	unknown	unknown

INTRODUCTION

Non-fuel mineral production in Colorado includes metals (other than uranium), industrial minerals, and construction materials. In 2000, the U.S. Geological Survey estimated a total value of non-fuel mineral production in Colorado of $566 million (preliminary). This is a 2 percent increase in value over the 1999 production value of $555 million. Most of the increase in value is due to increased sand, gravel, and crushed stone production. Colorado ranked 27th among the states in the value of the non-fuel minerals produced, down from 26th in 1999. Figure 33 shows the value of non-fuel mineral production in Colorado, and the percent of the total value of each commodity type. 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 14 lists the mines and prospects, their owners, mine type, and commodity.

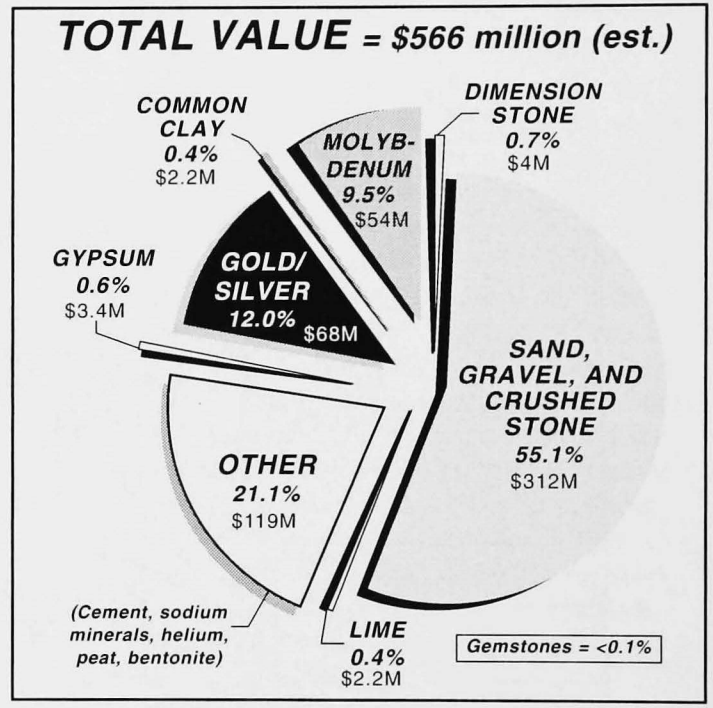

Figure 33. Value of Colorado non-fuel mineral production, 2000.

METAL MINING

Gold and Silver

The Cripple Creek and Victor Gold Mining Co. (CC&V) continues to operate the only major precious metals mine in Colorado. The Cresson Mine, near the towns of Victor and Cripple Creek in Teller County, produced 242,000 ounces of gold in 2000, up 4.5 percent from the 231,000 ounces produced in 1999. 2000 silver production at the mine is estimated at about 99,000 ounces. Based on the average prices for the metals over the entire year, the value of the gold produced is estimated to be $67.5 million, and the value of silver is estimated at about $0.5 million.

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. AngloGold is the world's largest gold producing company and is the operator of the mine. Golden Cycle Gold Corporation is based in Colorado Springs and has had a long-standing interest in mining in the Cripple Creek district.

Gold and silver prices remained very low in 2000, averaging $279 per ounce. Silver averaged $4.97 per ounce. 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 for 2003. The plan calls for a 50 percent increase in tonnage capacity. This will increase the annual rate of gold production to an estimated

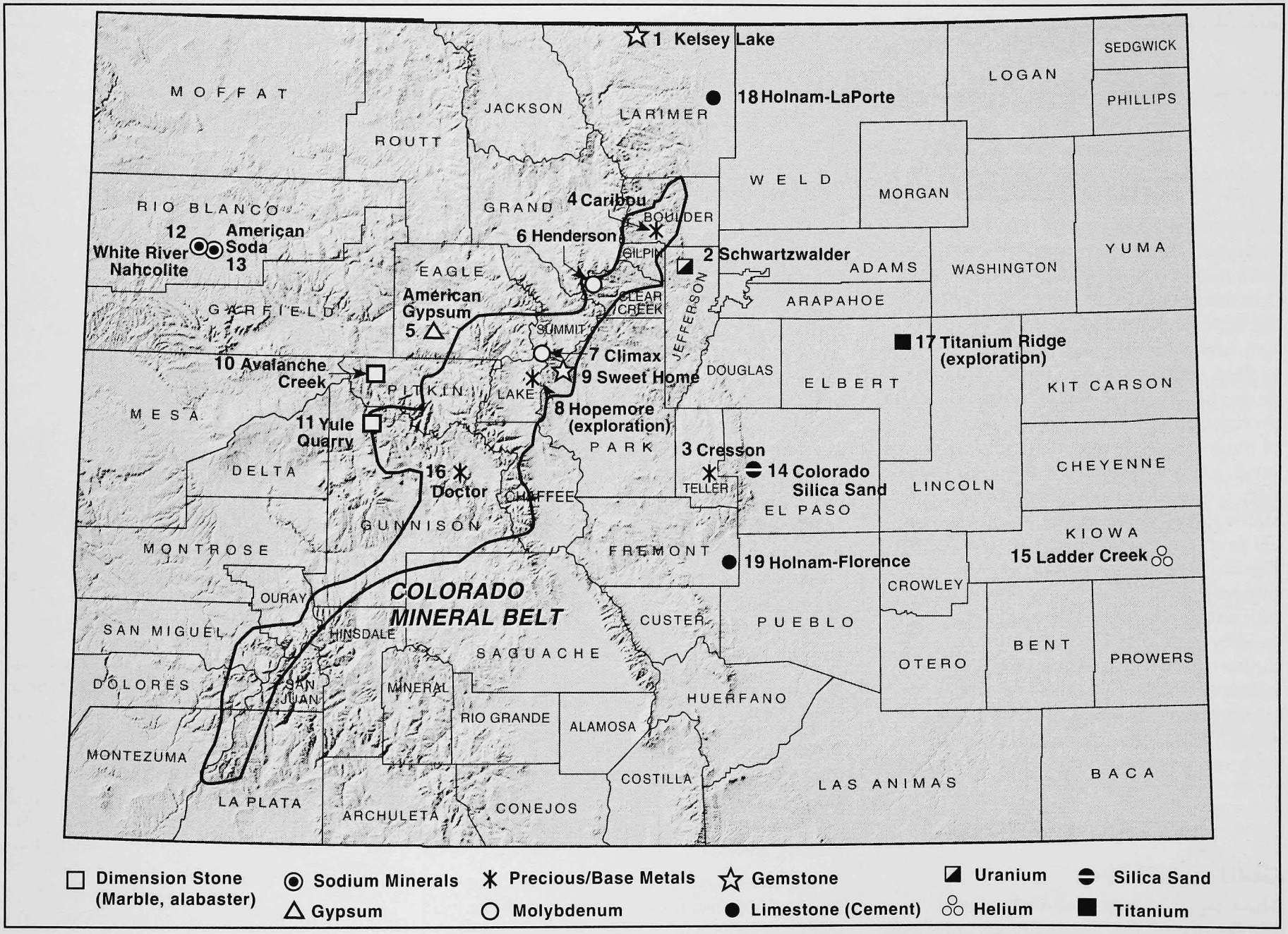

Figure 34. Map of major metal and industrial mineral mines and prospects.

Table 15. Major mineral producers and prospects in Colorado, numbers refer to mines in Figure 34.

Map No.	Mine Name	Commodity	Type	Owner/Operator
1	Kelsey Lake	Diamonds	OP	McKenzie Bay International, Ltd.
2	Schwartzwalder	Uranium	UG	Cotter Corp.
3	Cresson	Gold	OP	Cripple Creek & Victor Mining Co.
4	Caribou	Gold, silver, copper, lead,zinc	UG	Calais Resources, Inc.
5	American Gypsum	Gypsum	OP	Centex Construction Products, Inc.
6	Henderson	Molybdenum	UG	Phelps Dodge Corp.
7	Climax	Molybdenum	UG, OP	Phelps Dodge Corp.
8	Hopemore	Gold, silver	Exp	Leadville Mining and Milling Corp.
9	Sweet Home	Rhodochrosite	UG	Sweet Home Rhodo, Inc.
10	Avalanche Creek	Alabaster	UG	Rocky Mountain Stone Co.
11	Yule quarry	Marble	UG	Sierra Minerals Corp.
12	White River	Sodium bicarbonate	SOL	White River Nahcolite Minerals, LLC
13	American Soda	Soda ash, sodium bicarbonate	SOL	American Soda, LLC
14	Colorado Silica Sand	Silica sand	OP	Oglebay Norton Industrial Sands
15	Ladder Creek Plant	Helium	P	Duke Energy Field Services
16	Doctor	Zinc	Exp	Summo Minerals Corp.
17	Titanium Ridge	Titanium, zircon, garnet, coal	Exp	Radar Acquisitions Corp.

Abbreviations: TYPE: **UG**—underground; **OP**—open pit; **SOL**—solution; **Exp**—exploration

320,000 ounces per year. 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 2011 at the expanded production rate of over 300,000 ounces per year.

On April 21 2000, CC&V poured the 1,000,000th ounce of gold produced since 1994 when the present, modern operation was begun. Gold was originally discovered in the Cripple Creek district in 1891. Since then, the district has produced over 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.

ITEC Environmental Colorado, a Canadian company that had plans to reprocess old mine waste and tailings in Boulder County, abandoned those plans and sold off its land and other assets in 2000. ITEC had hoped to extract gold, silver, zinc, and copper that were left behind in the tailings by less efficient operators in the past. They had purchased the defunct Gold Hill Mill and about 700 acres of mining properties for the operation. The plan was backed by Boulder County because it would have cleaned up numerous old tailings and waste rock piles. The continued low gold prices that has resulted in numerous mine closures throughout the U.S. forced ITEC to abandon its plans in Boulder County.

Molybdenum

In December 1999, the Henderson Mine in Clear Creek County was acquired by Phelps Dodge Corp. of Phoenix, Arizona, when it purchased the assets of Cyprus-AMAX Minerals Co. The mine continues to be North America's largest primary producer of molybdenum. In 2000, the mine and mill produced an estimated 20 million pounds of contained molybdenum,

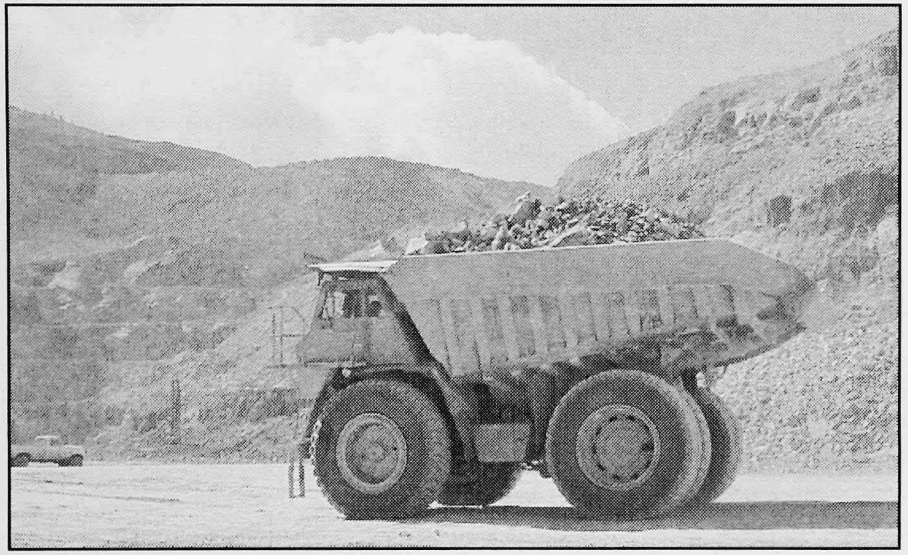

Figure 35. Haul truck loaded with ore from Cresson Mine near Cripple Creek.

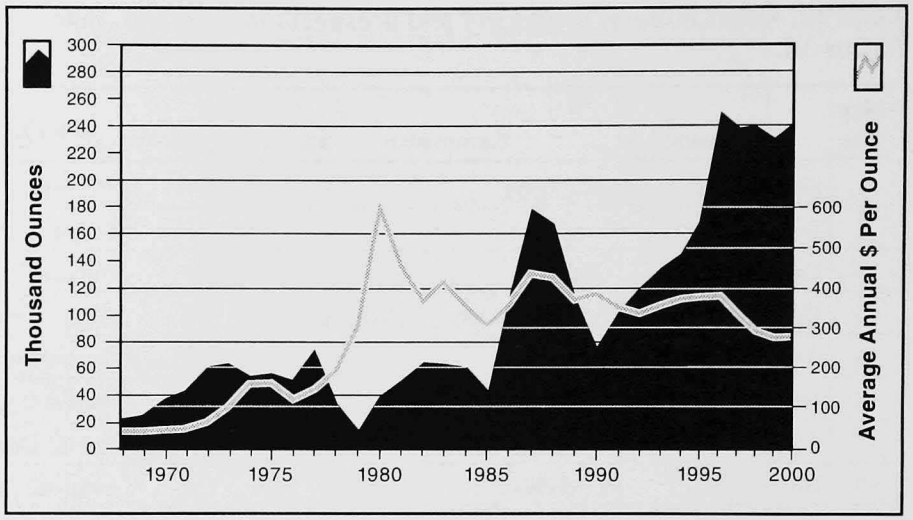

Figure 36. Colorado gold production and average gold prices, 1968-2000.

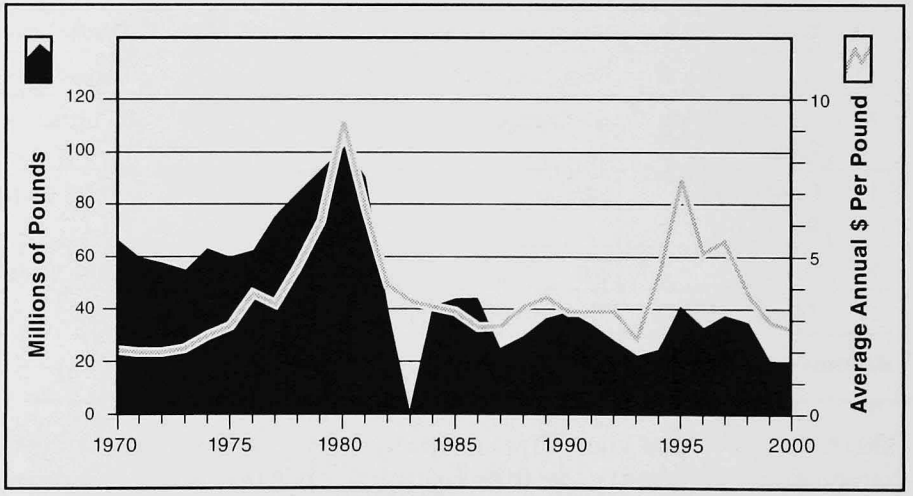

Figure 37. Molybdenum production in Colorado and average molybdenum prices, 1970-2000.

down 4.8 percent from the 21 million pounds produced in 1999. According to the U.S. Geological Survey Mineral Information Team, the 2000 average price for contained molybdenum was $2.68 per pound, slightly up from the $2.64 estimated in 1999. The estimated total value of molybdenum produced at Henderson in 2000 is $54 million. In a January 2001 press release, Phelps Dodge Corp. announced that its molybdenum operations incurred losses of $6.3 million in 2000 due to the continued low prices for the metal. They blame the low prices on excess molybdenum inventories worldwide. Total U.S. production of molybdenum was 71 million pounds, down 26 percent from 1999 domestic production.

In May 2000, the Henderson Mine cut 130 employees from its work force and cut production by 20 percent. The mine continues to employ about 320 workers at the mine and mill.

The Henderson Mine has completed the upgrade of its mine facilities known as "Henderson 2000". The new 10.5-mile single-flight underground conveyor, which replaced the former underground train haulage system, is now fully operational and transporting ore from the mine to the mill area. It is the world's longest

single-flight conveyor belt. In addition to this conveyor, two other shorter conveyor links were installed, a new 2500 ton-per-hour crusher system was built, and new 80-ton and 40-ton underground haul trucks were added. The efficiencies gained from the successful implementation of Henderson 2000 will enable the mine to lower its overall cutoff grade, and therefore increase its ore reserve.

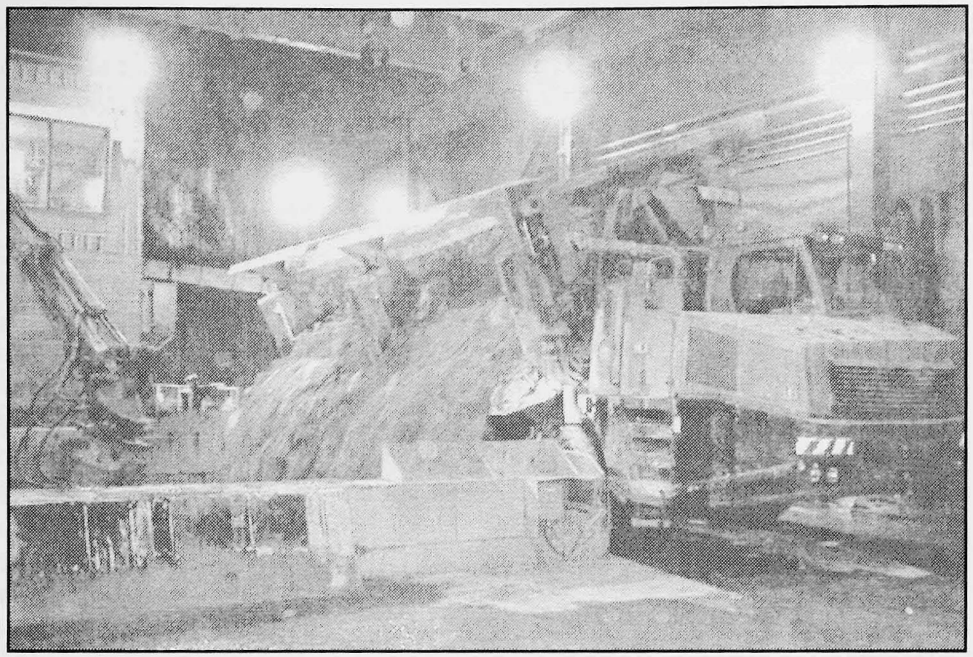

Figure 38. New 80-ton side-dump ore haulage truck delivering ore to underground crusher, Henderson Mine (photograph courtesy of Henderson Mine).

The Henderson orebody is elliptical in shape and lies about 3,500 feet beneath the summit of Red Mountain. It occurs within a Tertiary 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 0.28 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.

The Climax Mine between Leadville and Copper Mountain continues to be on standby and monitoring. The only activity is monitoring the local groundwater and surface water for possible contaminants. However, a large amount of ore remains unmined at the site. Should demand for molybdenum increase significantly in the future, the mine at Climax can be placed into operation again.

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 and is continuing. The Black Cloud 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.

Defined resources of base metals still exist in the Leadville district, as evidenced by Leadville Corporation's attempts to secure needed financing to begin production at its Diamond-Resurrection Mine. As of November 2000, the company has been unable to secure the funds necessary to develop the mine. Studies conducted over the past 12 years on the property have verified the existence of 800,000 tons of material containing "significant deposits of gold, silver, and base metals."

Uranium and Vanadium

In 2000, the price for uranium oxide continued its steady decline that began in July 1996, when it reached a high of $16.60 per pound. As of December 2000, the spot price was $7.10 per pound. These low prices combined with increasingly expensive mining costs forced Colorado's only active uranium mine to close. Colorado uranium production came to an end in March 2000 when the Schwartzwalder Mine 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 mine site is undergoing reclamation. However, if prices for uranium go up substantially, the mine is still positioned to re-open since the orebodies are not completely exhausted, and the infrastructure is still in place. The estimated gross value of uranium mine production in Colorado in 2000 is $0.7 million.

General Atomics of San Diego purchased Cotter Corporation, the owner of the Schwartzwalder Mine, in March 2000. Cotter was previously a subsidiary of Commonwealth Edison Co. of Chicago. Cotter Corporation will continue to operate its uranium mill in Canon City, Colorado. The mill finished processing the ore stockpiled from the Schwartzwalder Mine, but will continue to produce uranium from alternative feedstock, possibly including recycling of previously manufactured items that contain uranium. Other sources may be ore from private or government stockpiles. Cotter Corp. is developing processes to treat alternative feedstock material.

No vanadium was produced in Colorado in 2000. In June 1999, International Uranium Corporation's Sunday Mine complex in San Miguel County ceased all uranium and vanadium production. The mine had only been operating since July 1997.

Industrial Minerals and Construction Materials

Introduction

The most economically significant segment of the construction material industry in the state is sand, gravel and crushed stone. Other important construction materials and industrial minerals produced in Colorado include soda ash, sodium bicarbonate, gypsum, dimension stone, silica sand, and gemstones. Other construction materials and industrial minerals produced in the state during 2000 but not discussed in this report include peat, bentonite clay, common clay, and kaolin.

Sand, Gravel, and Crushed Stone

Colorado ranked seventh in the U.S. in 2000 for the production of construction sand and gravel. The U.S. Geological Survey has estimated that in Colorado, the sand, gravel, and crushed stone industry produced approximately 67.1 million tons of material in 2000, up 5.9 percent from the 63.4 million tons produced in 1999 (Figure 39). The value of the production increased to $312 million, up 12.9 percent over the 1999 value of $276 million. The prices for these construction materials has been increasing for the last several years due to high demand generated by population growth and a strong economy, especially along the Front Range. The dip in

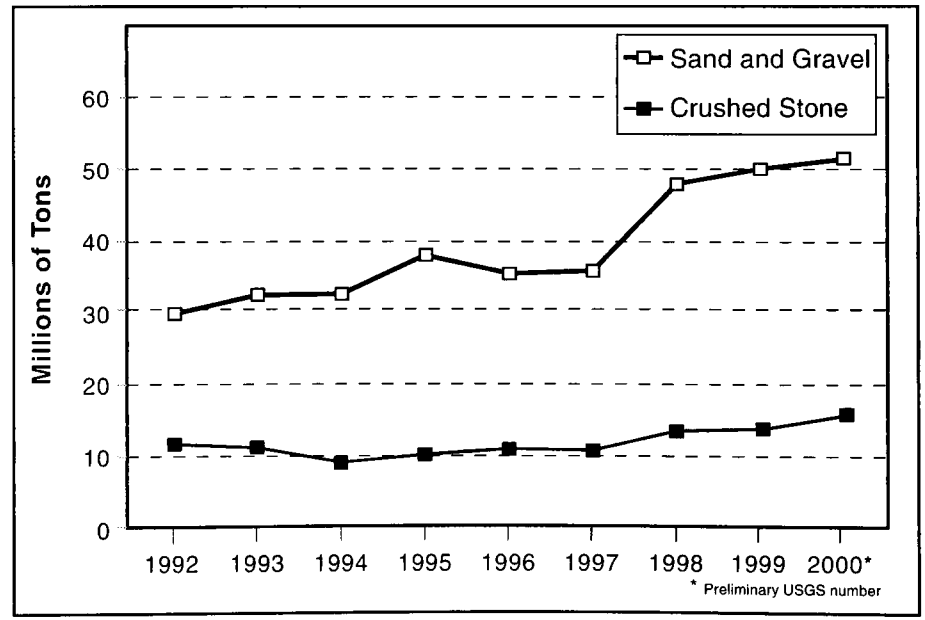

Figure 39. Production of sand and gravel vs. crushed stone in Colorado, 1992-2000

prices for crushed stone in 1997 and 1998 is interpreted to correspond with the decreased demand for the material after the construction of Denver International Airport was completed (Figure 40).

Soda Ash and Sodium Bicarbonate

Industrial mineral production in Colorado took a large leap forward in October 2000 when American Soda, LLC began production of soda ash and sodium bicarbonate. In less than one year, the company built a state-of-the-art mine, 44-mile pipeline, processing plant, and railroad spur to produce and ship its sodium products. The mine and plant have a designed production capacity of 1 million tons per year of soda ash and 150,000 tons per year of sodium bicarbonate.

The solution mine, located in Rio Blanco County within the Piceance 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 BLM land. They estimate that the nahcolite in situ resource is 3.5 billion tons, with over 1 billion tons of recoverable nahcolite.

The dissolved sodium bicarbonate is converted to sodium carbonate (soda ash) at a plant near the well field. Still in a hot solution, the soda ash is pumped through one of the two new 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.

The processing plant was built on the site of the former oil shale plant, which American Soda purchased from Unocal. It processes the solution into crystalline soda ash. It also converts some of the solution back into sodium bicarbonate using carbon dioxide that is generated at the mine plant during the conversion of sodium bicarbonate to sodium carbonate. The soda ash is shipped out in custom-designed railcars, while the sodium bicarbonate is bagged and shipped by truck.

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 new mine. White River produced 102,000 tons of sodium bicarbonate in 2000. This continues a five-year upward trend in the mine's production. The mine's designed capacity is 125,000 tons per year. Both food grade and industrial grade products are produced.

Soda ash (Na_2CO_3) is used primarily to manufacture glass, soap and detergents, and other chemicals. Another major use is to remove sulfur dioxide

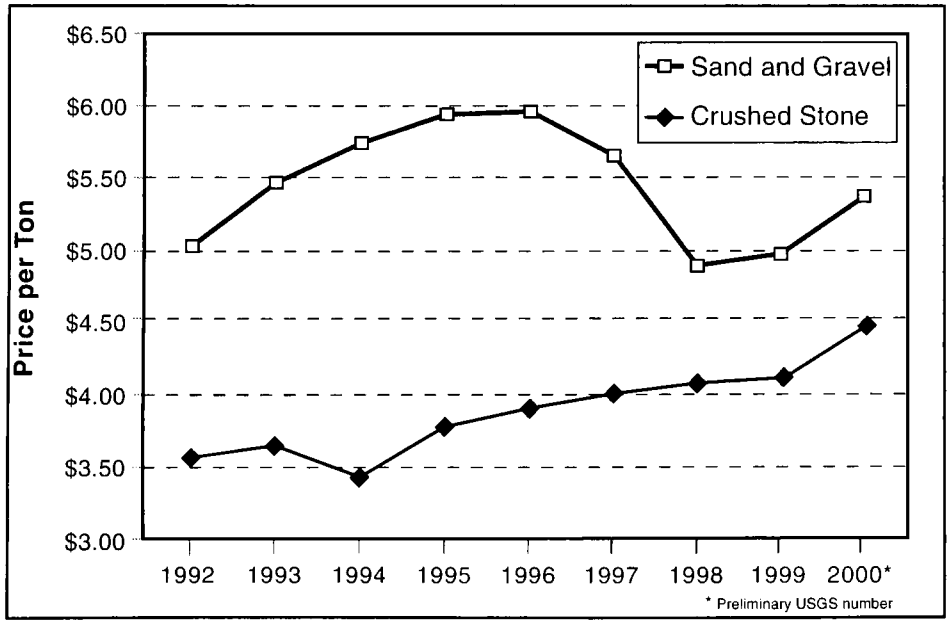

Figure 40. Average estimated price per ton of sand and gravel vs. crushed stone in Colorado, 1992-2000.

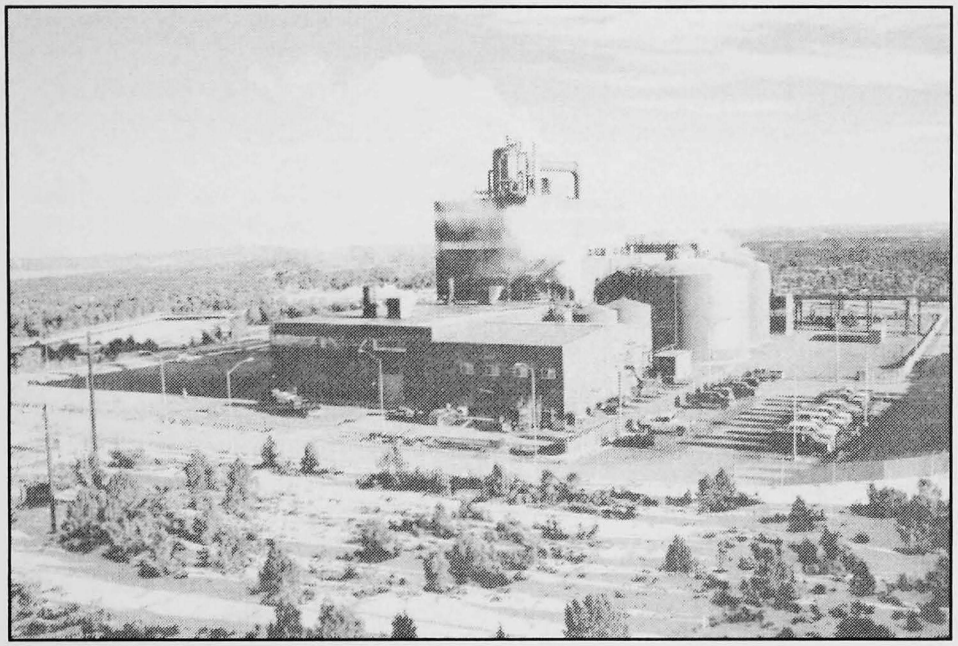

Figure 41. American Soda plant at the nahcolite solution mine, Rio Blanco County (photograph courtesy of American Soda).

from power plant emissions. Sodium bicarbonate ($NaHCO_3$), also known as baking soda, is used in food products, animal feed, cleaning products, and pharmaceuticals.

Gypsum

According to the U.S. Geological Survey, the total production of gypsum in Colorado in 2000 was 617,000 tons valued at $3.54 million. Gypsum is used primarily for the manufacture of wallboard and plaster products, cement manufacture, and as a soil conditioner. A compact variety of fine-grained gypsum known commonly as alabaster is used as stone for sculptures and decorative items. Alabaster is quarried in two Colorado locations.

Centex Construction Products, Inc.'s American Gypsum operation produced 580,000 tons of gypsum in 2000 from its gypsum mine near the town of Gypsum in Eagle County. That figure is an increase of 29 percent over the 1999 production of 450,000 tons. The gypsum ore is mined from an open pit using pavement profiler machines that cut a trench 12 feet wide by 0.5 feet deep. 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. In April 1999, the company completed an $18 million, two-year expansion program to increase the production capacity of the mine and plant by 60 percent. Production over the next few years is projected to remain at the plant's capacity of about 580,000 tons. The mine and plant employ approximately 120 people.

Smaller gypsum quarries in Fremont and Larimer Counties produce gypsum for cement manufacture and for soil conditioners.

Cement

Cement production continued at a high pace in Colorado in 2000. Holnam, Inc. operates two 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 currently produces about 1 million tons per year using the wet process. However, it is undergoing a $200 million plant expansion that will double the capacity to 2 million tons per year. The plant is also being converted from the multi-kiln wet process to a single-kiln dry process. The newly upgraded plant is forecast to begin production in June 2001.

Both the Portland plant and the La Porte plant mine 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

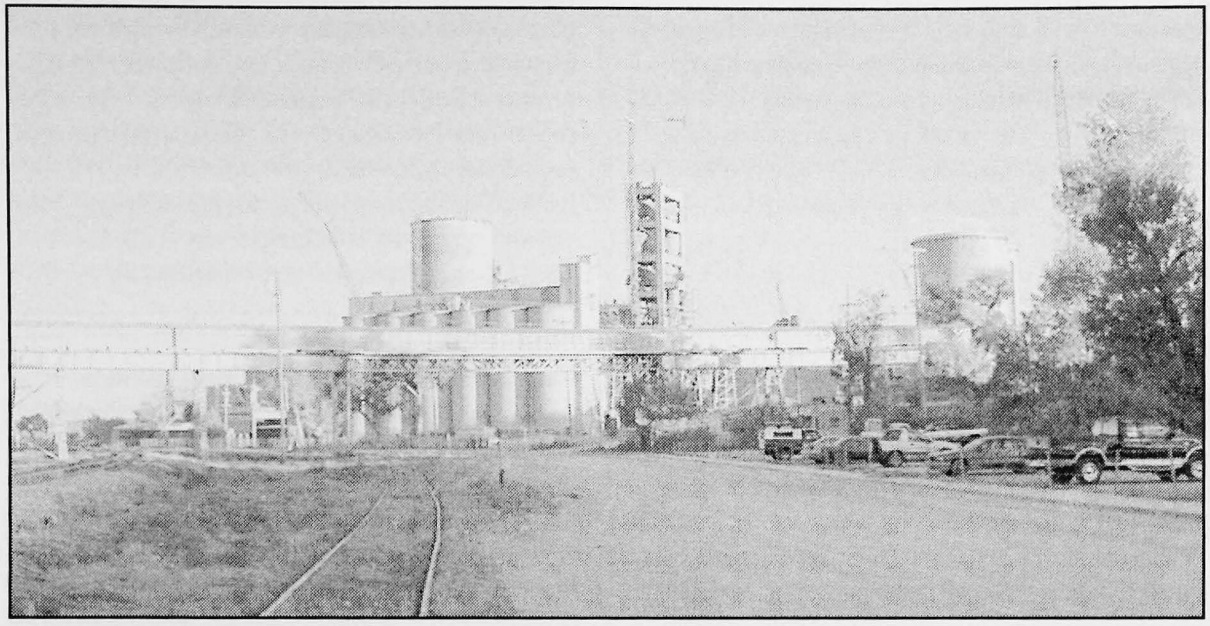

Figure 42. Construction activities at the Holnam, Inc. cement plant near Florence, Colorado.

ore is mined locally, near the cement plants.

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.

Dimension Stone

In 2000, 20,100 tons of dimension stone with an estimated value of $4.1 million was quarried in Colorado. This production represents a 35 percent increase in tonnage from the 13,600 tons produced in 1999.

The Yule Quarry in Gunnison County continued to produce fine quality white marble for use as tile and slab, decorative stone, and monuments. The owner of the quarry is Sierra Minerals Corp. of Englewood, Colorado. The stone is marketed under the name Colorado Yule Marble. The quarry generated a small profit for the first time in modern history, according to Sierra Minerals.

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.

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 (a form of gypsum) has been quarried since 1998 at Rocky

Mountain Stone Company's Avalanche Creek site in Pitkin County. The white, black, and gray material is used mainly as a sculpting medium and for other purposes such as high-end decorative tile and table tops. Robert Congdon, the owner of the underground quarry, has been active in promoting the use of alabaster as a sculpting medium, and has hosted several stone sculpting exhibits at Rocky Mountain Stone's sales office at the old Mid-Continent Coal load-out plant east of Carbondale.

Alabaster has been quarried in small quantities since 1969 at a site in the foothills northwest of Fort Collins by Colorado Alabaster Supply. Most of the stone is used as a sculpture medium. The stone is mostly of white, pink, or gray color.

Gem and Specimen Minerals

In 2000, the reported value of gemstones and specimen minerals produced in Colorado is $274,000. This represents a slight increase from the 1999 value of $262,000.

In early September 2000, the Kelsey Lake diamond mine near the Wyoming border in Larimer County began operations again after being shut down since 1998. It is the only commercial diamond mine in the U.S. The Great Western Diamond Co., a subsidiary of the Canadian company McKenzie Bay International Ltd., is the owner and operator of the project. It bought the property from the previous owner and operator, Redaurum Ltd., in 1999. 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.

The Kelsey Lake Mine is an open pit operation on two kimberlite pipes, 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 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 a vice president 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.

With a $2 million investment in new equipment since purchasing the mine, the Great Western Diamond Company has made substantial improvements in operating efficiencies and security procedures. The new equipment includes an X-ray scanner that is expected to increase diamond recovery to nearly 100 percent. The mine and recovery plant employs about 25 people at full production.

The Sweet Home Mine near the town of Alma in Park County continues to produce the most prized specimen-quality rhodochrosite crystals in the world. Since 1991, the former silver mine has produced the beautiful cherry red crystals from open cavities in hydrothermal quartz-calcite-sulfide veins. Some of the larger crystals have commanded prices over $100,000.

Helium

Grade-A helium is produced at two plants in southeastern Colorado. The helium is produced by separating it from natural gas. It is liquified at minus 458° F. Helium is used for several purposes including cryogenic applications (24 percent), pressurizing and purging (20 percent), welding cover gas (18 percent), and controlled atmospheres (16 percent). The total U.S. production of helium in 2000 was estimated by the U.S. Geological Survey to be 4.2 billion cubic feet, with an estimated value of $215 million. The Colorado portion of this production has not been separately determined. Only four other states, Kansas, Texas, Oklahoma, and Utah, produce helium.

Exploration and Development Activity

Metals Exploration and Development

Cresson Mine

Exploration for additional reserves con-

tinued in 2000 at the Cresson Mine near Cripple Creek and Victor. CC&V drilled approximately 250,000 feet of exploration drilling in 2000, and an equal amount is planned for 2001. Part of the new exploration will be deep core drill holes targeting high-grade vein systems that have potential for underground mining. The current reserve base is sufficient to support gold production until 2011 at the expanded production rate of over 300,000 ounces per year. In June 2000, CC&V announced that exploration drilling had increased the measured ore reserve to 4.9 million ounces compared to 4.3 million ounces at the end of 1998. This increase takes into account the depletion due to ongoing mining. The company estimates that the reserve, plus non-reserve mineralized material, contain approximately 10 million ounces of gold.

Doctor Mine

Summo Minerals Corporation of Denver completed 18 exploration holes in 2000 on the Doctor Mine zinc exploration project in Gunnison County. Zinc occurs mainly as the carbonate mineral smithsonite. This preliminary drilling identified a steeply dipping zone of zinc oxides averaging 50 feet wide, 125 feet thick, and at least 500 feet long grading 6.38 percent zinc. Summo believes that the Doctor Mine has the potential to produce up to 100 million pounds of zinc annually at a cash cost of less than $0.30 per pound. The price for zinc averaged $0.51 per pound in 2000.

Hopemore Mine

Leadville Mining and Milling Corp. continued exploration activities at its Hopemore Mine near Leadville. The company completed its Phase I and Phase II reverse-circulation surface drilling programs that tested shallow gold-silver mineralization on Breece Hill near the Hopemore Mine. Phase III drilling began in the fall of 2000 but was terminated by heavy snow. The program will continue in the spring of 2001. The surface drilling programs targeted promising areas identified by geologic mapping and geophysical exploration methods, which revealed a magnetic anomaly. Underground core-drilling activity also continued into 2000, with several zones of gold-silver mineralization being encountered. The company has also been actively expanding its land position in the Leadville mining district.

Caribou District

The Consolidated Caribou Mines Project near the old mining camp of Caribou in Boulder County has undergone sporadic exploration for gold and silver since the early 1970s. The current owner of the exploration project is Calais Resources Inc. of British Columbia. The estimated metal resources for this project include 424,000 ounces of gold and 11.7 million ounces of silver, plus potentially recoverable quantities of lead, zinc, and copper. Additional exploration targets remain untested on the property and Calais has plans developed for additional work. In 2000, no major exploration activity was reported by Calais for this project. The company was active in consolidation of its land position in the district. As part of one deal, Calais deeded 14.5 acres of property with low mineral potential to the Boulder County Park and Open Space Department for the preservation of an historic site.

Figure 43. Underground exploration drilling at the Hopemore Mine near Leadville, Colorado.

Platinum Group Metals

Market prices for the platinum group metal (PGMs), primarily platinum and

palladium, have increased markedly during 2000. Supply disruptions in Russia, the world's largest producer of palladium, caused the price of that metal to jump from $457 per ounce in January 2000 to $1057 per ounce in January 2001, a 131 percent increase. Platinum prices increased 41 percent, from $444 per ounce to $625 per ounce in the same time period. These dramatic price increases have spurred exploration for the PGMs in the U.S. and around the world.

Several areas in Colorado are possibly prospective to host significant PGM mineralization. In South Africa, Russia, and at the Stillwater Mine in Montana, platinum group elements are mined primarily from layered or zoned mafic-ultramafic intrusive complexes. Several of these mafic-ultramafic complexes are present in the mountainous region of Colorado. It is rumored that at least one mineral exploration company is actively searching for PGMs in the state.

Industrial Minerals Development

Cement

A large, new cement plant was approved southeast of Pueblo. The Rio Grande Portland Cement Corp., a subsidiary of the Mexican company, Grupo Cementos de Chihuahua, plans to build the $165 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. Construction is slated to begin sometime in 2001.

Nahcolite

Ameralia, Inc. continued development work on their planned in situ solution nahcolite mine in the Piceance Basin near the currently operating American Soda and White River Nahcolite mines. Ameralia plans to produce sodium bicarbonate at a rate of 150,000 tons per year. In late 1999, the Bureau of Land Management approved the companies development plans. In 2000, the company drilled and completed several monitoring wells to collect baseline groundwater data prior to solution mining activity. Core drilling and resource evaluation work performed in 1996 on the company's 1,320 acre Rock School Lease determined a nahcolite mining interval height of 510 feet that averaged 26.4 percent nahcolite.

Titanium

Radar Acquisitions Corp. of Calgary, Alberta is actively pursuing its Titanium Ridge project on the plains of eastern Colorado near the town of Limon. Titanium minerals (ilmenite and rutile), garnet, zircon, and some rare earth minerals occur as 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. The company is presently conducting a feasibility study on the project, which covers a total of about 13,000 acres. On the portion of the property drilled so far (about 1,600 acres), a consulting engineering firm has determined a heavy mineral resource of 18 million tons, and approximately 100 million tons of lignite coal. Radar has also completed tests on bulk samples to determine the appropriate methods for recovering the heavy minerals. Titanium is primarily used as pigment in paint and plastic. Zircon is used in ceramics, TV tubes, glass, and enamel. Garnet is used as an abrasive blast cleaning agent, waterjet cutting, and water filtration.

Teck Corp. of Vancouver, B.C. continues to hold the mineral rights to the enormous White Earth titanium deposit near Powderhorn in Gunnison County. The deposit has an estimated mineral resource of 1.5 billion tons, grading 10.9 percent titanium dioxide using an 8 percent TiO_2 cut-off grade. This is believed to be the largest titanium resource in the U.S. The primary mineral at this deposit is perovskite. Although perovskite has never previously been used as a feedstock in the titanium pigment industry, in 1997 the company developed a pilot plant that demonstrated the ability to make commercial quality pigment from concentrates of this mineral. The company has not reported any new activity on this project in 2000.