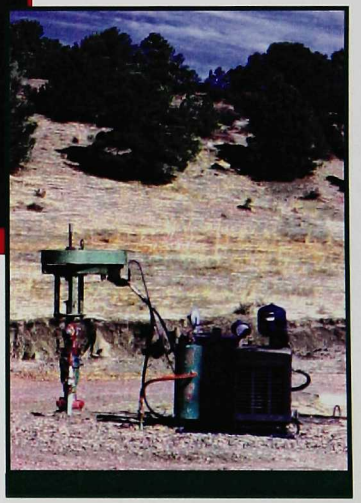
Information Series 54

Colorado Mineral and Mineral Fuel Activity, 1999

By James A. Cappa,
Christopher J. Carroll, and
H. Thomas Hemborg



Colorado Geological Survey
Division of Minerals and Geology
Department of Natural Resources
Denver, Colorado
2000

CONTENTS

Information Series 54

Colorado Mineral and Mineral Fuel Activity, 1999

By James A. Cappa, Christopher J. Carroll, and H. Thomas Hemborg

DOI: https://doi.org/10.58783/cgs.is54.rfoq1650

Colorado Geological Survey
Division of Minerals and Geology
Department of Natural Resources
Denver, Colorado / 2000

Cover (clockwise from upper left): Foidel Creek Mine stockpile; Foidel Creek Mine longwall shearer and miner (courtesy Twentymile Coal Co.); Evergreen Resources well in Spanish Peak coalbed methane field; Craig Power Plant; Niobrara Limestone at Holnam cement plant in La Porte

FOREWORD

The purpose of Colorado Geological Survey Information Series 54, *Colorado Mineral and Mineral Fuel Activity, 1999* is to describe exploration, development, and production activity of the gas and oil, coal, and mineral industries of the state in 1999. 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.

James A. Cappa
Chief, Mineral Resources and Geological Mapping Section

Vicki Cowart
State Geologist and Director

INTRODUCTION AND ECONOMIC FACTORS

The Colorado Geological Survey Mineral Resources Section estimates the total value of 1999 mineral and mineral fuel production in Colorado to be $2,835 million dollars, a two percent increase from the 1998 total value of $2,769 million (Fig. 1). Mineral fuel production values for 1999 are estimated at:

- oil—$326 million
- natural gas—$1,504 million
- carbon dioxide—$83 million
- uranium and vanadium—$7 million

The total value of oil, natural gas, and carbon dioxide production in 1999 was $1,913 million, a 12 percent increase from the 1998 value of $1,714 million. A higher oil and natural gas price is the primary reason for the increase in value for 1999.

Coal production increased from the 1998 level of 29.6 million tons to a new record of 29.9 million tons in 1999. Coal prices, which vary from mine to mine, are estimated at an average $12 per ton for 1999. The value of Colorado coal production is estimated at $360 million.

The U.S. Geological Survey Mineral Information Office estimates the value of the 1999 non-fuel mineral production to be $555 million. This figure is a decrease of eight percent from the 1998 value of $604 million. The decreased value is mostly due to lower molybdenum prices, decreased molybdenum production, and the closure of the Black Cloud Mine.

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 1999 decreased 7 percent to $38.48 million from $41.17 million in 1998. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (Fig. 2).

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

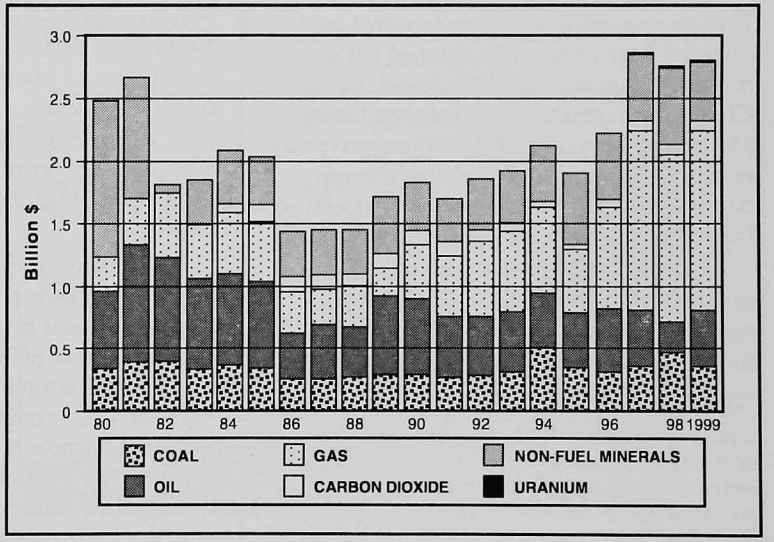


Figure 1. Value of Colorado mineral and mineral fuel production.

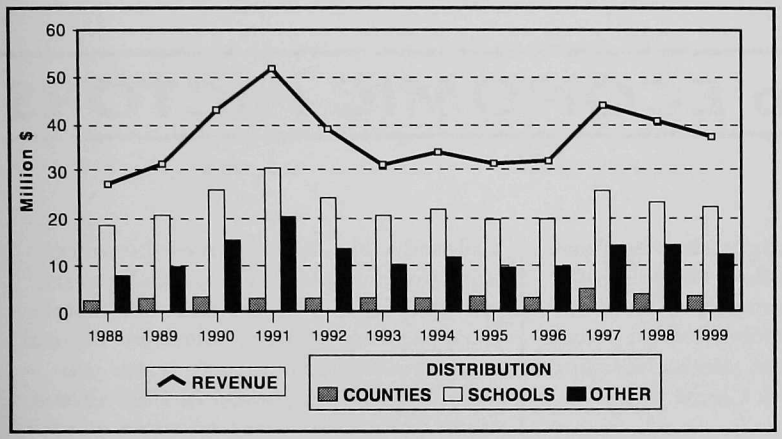


Figure 2. Federal mineral lease revenue and distribution in Colorado.

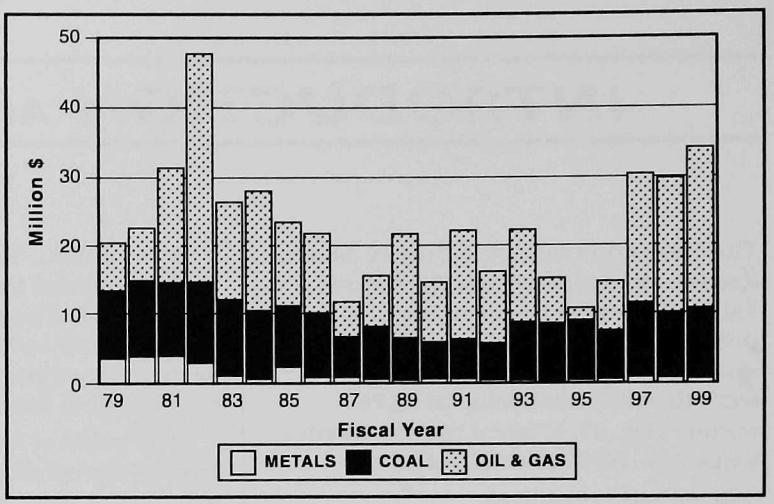


Figure 3. Colorado severance tax collections.

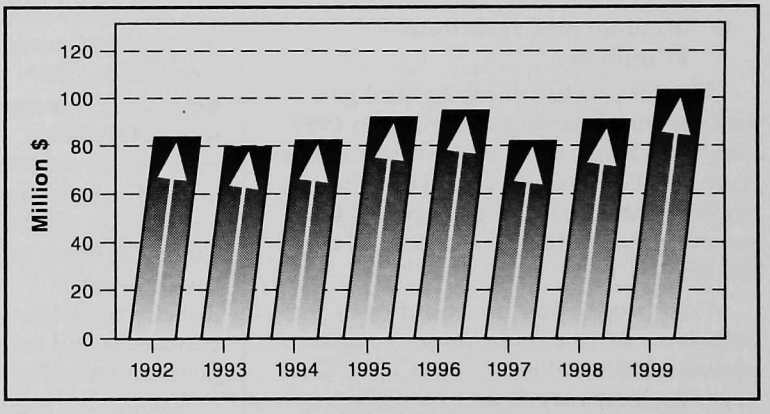


Figure 4. Property tax revenues from mineral properties.

collections in fiscal year 1999 totaled $33.9 million (Fig. 3).

Estimated property taxes paid in 1999 to the counties from mineral and mineral fuel properties totaled $104 million* (Fig. 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 1999 to be 13,700 workers, down about two percent from the 14,000 employment level in 1998. 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.

* This year we changed the basis upon which we compile property tax information; for ease of data gathering we have eliminated taxes collected on certain capital items. This results in an approximate 30 percent reduction in the amount of tax reported.

COAL

Despite increasing competition from other coal producing states, deregulated electric utilities, stricter environmental regulations and transportation ownership changes, the demand for Colorado coal has defied the marketplace and again showed strength in 1999. For the third straight year, coal mines in Colorado increased production to an all-time level, breaking the annual state coal production record (Fig. 5). The market for coal is ever-changing as increased competition from Wyoming's Powder River Basin (PRB) stresses coal sales, even for high quality Colorado coal. As the national spot market price of coal drops further, coal companies must lower the cost of production by increasing volume sales from fewer and more efficient coal mines, a trend that will continue into the next century.

Production and Historic Data

Colorado coal companies nearly surpassed the 30 million ton production mark by mining a record 29,981,574 tons of coal in 1999, a 1.2 percent increase over 1998. Colorado ranks twelfth nationally in coal production. Coal production was supplied during 1999 from 12 mines: eight underground and four surface operations. Coal was produced from nine of Colorado's 63 counties in 1999—Delta, Fremont, Gunnison, La Plata, Mesa, Moffat, Montrose, Rio Blanco, and Routt (Fig. 6). The three largest producing mines, Foidel Creek (Twentymile), West Elk, and Colowyo together accounted for over 70 percent of the state production. The largest producer was Twentymile Coal Company's Foidel Creek underground mine in Routt County with 8.55 million tons, again setting the state production record with the highest annual production from a single coal mine, and the national record for the most coal ever produced from a single longwall operation. Mountain Coal Company's West Elk underground mine in Gunnison County was the next highest producer with 7.09 million tons. During December 1999, West Elk produced more coal monthly (762,468 tons) than the Foidel Creek Mine. Despite a temporary shutdown in early 2000, West Elk is on pace to become the state's leading coal producer. Moffat County's Colowyo Mine was the third most pro-

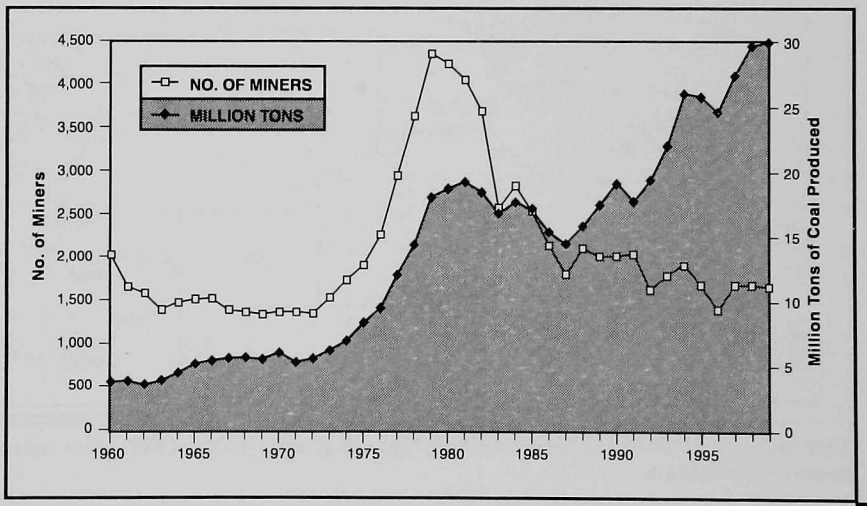


Figure 5. Coal production and miners employed in Colorado, 1960–1999.

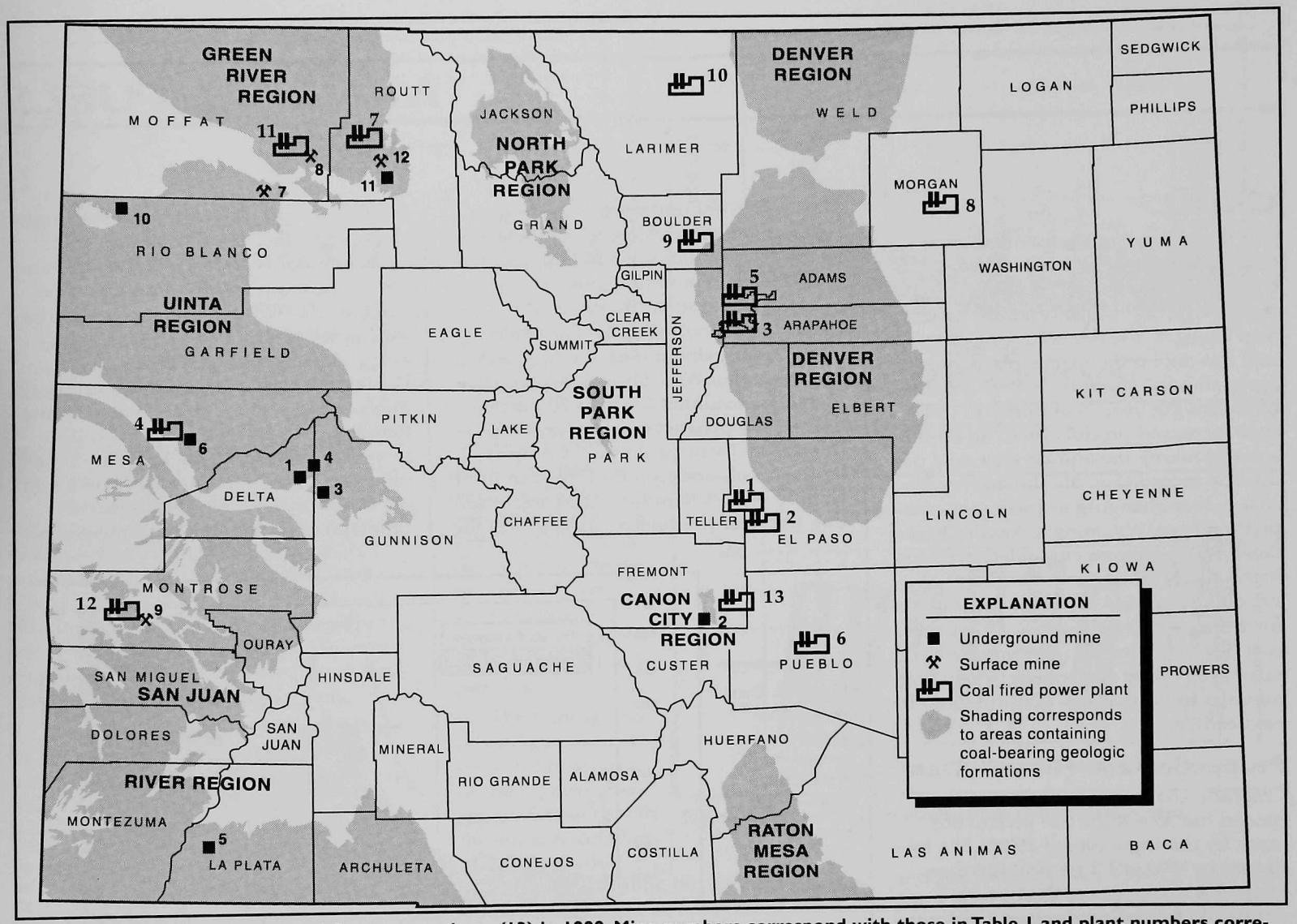


Figure 6. Coal mines (12) and coal fired power plants (13) in 1999. Mine numbers correspond with those in Table 1 and plant numbers correspond with Table 5.

Table 1. Colorado coal mine production statistics, 1999. See Figure 6 for mine locations. (Source: Colo. Div. 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	1999 Prod. (tons)	Dec 1999 Miners	Shipment Method
1	**Bowie #2**	Delta	Uinta	Somerset	Bowie Resources Ltd.	13S, 91W	Mesaverde	D	9–12	11,800	U	Continuous	1,748,007	156	Truck, rail
2	**Southfield**	Fremont	Canon City	Canon City	Energy Fuels Coal, Inc.	20S, 69W	Vermejo	Dirty Jack-O-Lantern Red Arrow	6 5.5	11,050	U	Continuous	242,197	32	Truck
3	**West Elk**	Gunnison	Uinta	Somerset	Arch (ACI) Mountain Coal Co.	13S, 90W	Mesaverde	B	14	11,650	U	Longwall, continuous	7,091,972	249	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	962,226	158	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	245,719	32	Truck
6	**Roadside (S. Portal)**	Mesa	Uinta	Grand Mesa	Powderhorn Coal Co. (Peabody)	11S, 98W	Mesaverde	Cameo B	4.4–9.4	11,300	U	Continuous	284,540	30	Conveyor
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	5,569,385	294	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.	2,219,053	119	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	359,405	26	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	1,336,659	137	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	8,555,948	337	Rail
12	**Seneca II, 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	1,363,463	89	Truck, rail
Total													**29,981,574**	**1,659**	

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

ductive mine in the state, and the most productive surface mine at 5.57 million tons (Table 1).

In 1999, 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). More coal was produced in Routt County than any other single county with over 9.92 million tons of coal from both the Foidel Creek Mine and the Seneca and Yoast Mines near Hayden (Fig. 7).

According to historic state coal records the amount of coal produced in Colorado from 1864 through 1999 now totals 1,053 million tons reported. Most of that coal was produced in the Uinta Coal Region with 294.06 million tons of coal from Delta, Garfield, Gunnison, Mesa, Moffat (in part), Pitkin, and Rio Blanco Counties, or 27.9 percent of the statewide historic total (Table 2). The Uinta Coal Region surpassed the Green River Coal Region (cumulative coal production of 290.58 million tons) as the cumulative coal production leader in the state with last year's production level adding 17 million tons to the total.

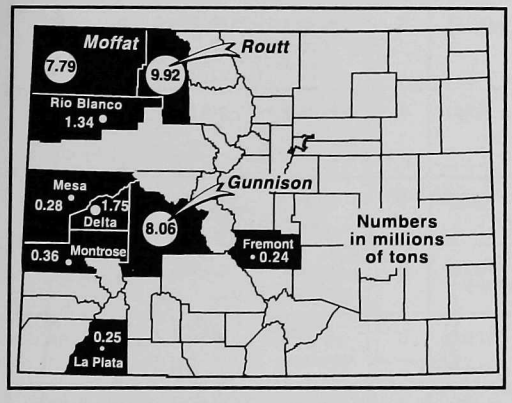
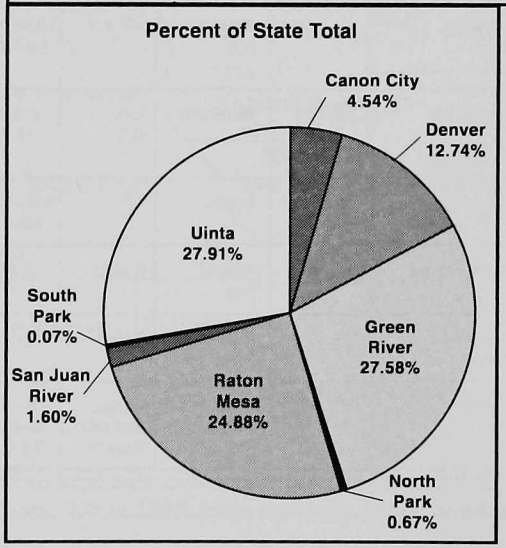


Figure 7. Colorado coal producing counties, 1999. Number is the amount of coal produced in millions of tons. Size of circle indicates relative amount of coal production in each county.

Table 2. Cumulative coal production in Colorado by coal region, 1864–1999 with accompanying graph. See Figure 6 for coal region map.

Coal Region	County	Production (millions of tons)	Percent of State Total
Canon City	Fremont	47.81	4.54
Denver	Adams, Arapahoe, Boulder, Douglas, Elbert, El Paso Jefferson, Larimer, Weld	134.20	12.74
Green River	Moffat, Routt	290.58	27.58
North Park	Jackson	7.07	0.67
Raton Mesa	Las Animas, Huerfano	262.09	24.88
San Juan River	Archuleta, Dolores, La Plata, Montezuma, Montrose Ouray, San Miguel	16.88	1.60
South Park	Park	0.72	0.07
Uinta	Delta, Garfield, Gunnison, Mesa, Moffat, Pitkin, Rio Blanco	294.06	27.91
Total		**1,053.40**	**100.00**



Economic Impact

According to the Colorado Division of Minerals and Geology, Colorado's coal mines in 1999 employed 1,659 miners (Table 3), a decrease of only 6 miners

Table 3. Colorado coal production and miners employed by county, 1999.

County	Production	No. of miners	No. of Mines Surface/ Underground
Delta	1,748,007	156	0/1
Fremont	242,197	32	0/1
Gunnison	8,057,198	407	0/2
La Plata	245,719	32	0/1
Mesa	284,540	30	0/1
Moffat	7,788,438	413	2/0
Montrose	359,405	26	1/0
Rio Blanco	1,336,659	137	0/1
Routt	9,919,411	426	1/1
Total	**29,6981,574**	**1,659**	**4/8**

over the 1998 level. This number includes both miners and surface support staff, but not administrative and supervisory personnel. The Colorado State Legislature passed a bill in 1999 reducing the amount of severance tax that mining companies pay annually. This cost saving to the coal industry is substantial and comes at a time when many mines are marginally profitable. In 1999, the state collected $10.16 million in severance taxes from coal mines. Also in 1999, the State Land Board collected $2.48 million in royalties and rentals from coal properties.

Using a price of $12 per ton, the mine value of Colorado coal produced in 1999 was $359.8 million. This $12 price is an average of the 1999 spot market price for coal in Colorado, which fluctuated during the year between $10 to $14 per ton. Large surface lignite mines in the PRB of Wyoming once again increased production over 10 percent from 1998 to 1999, driving the price of coal down substantially nationwide. These large volumes of low cost coal which now sell for less than $5 per ton have forced producers throughout the nation to increase productivity to remain competitive. Many long-term contracts, as of 2000, are becoming rare. This competitive edge of the coal business is reflected in operational changes at Colorado's coal mines: higher productivity, fewer miners, and more efficient coal-cutting machinery.

The changing electric power market should be good for coal as deregulation usually increases use of lower cost input products, and coal is less costly than gas, nuclear, or other sources. Deregulation of the electric utility market has yet to make a full impact on the coal industry, but along with environmental credits and stricter regulations the utility market is sure to change an already very competitive coal business by 2001. The days of the small coal company are dwindling, replaced today by larger coal companies that survive by producing large volume coal sales when faced with decreasing profitability.

Coal Geology and Reserves

Colorado coal occurs primarily in Cretaceous age bituminous and subbituminous coal-bearing formations. In 1999, coal was mined from the Mesaverde Group (Williams Fork and Menefee Formations), Dakota Sandstone, and the Vermejo Formation. Nine of the twelve mines are located in the Uinta or Green River coal regions and produce from the Mesaverde Group. Coal seams mined by surface methods ranged from 1.6- to 20.4-feet thick (Fig. 8). Underground-mined coal seams range from 5- to over 20-feet thick (although the actual maximum thickness recovered is 12 feet). The current maximum depth is 2,100 feet.

The Department of Energy-Energy Information Agency (EIA) estimates that Colorado's demonstrated coal reserves (Fig. 9) are about 16.8 billion tons placing Colorado 8th in the U.S. in total demonstrated reserves (1998 data). EIA statewide estimates that 12.1 billion tons of the demonstrated reserve base are minable underground and 4.7 billion tons are surface minable. More recent coal reserve studies by the Colorado

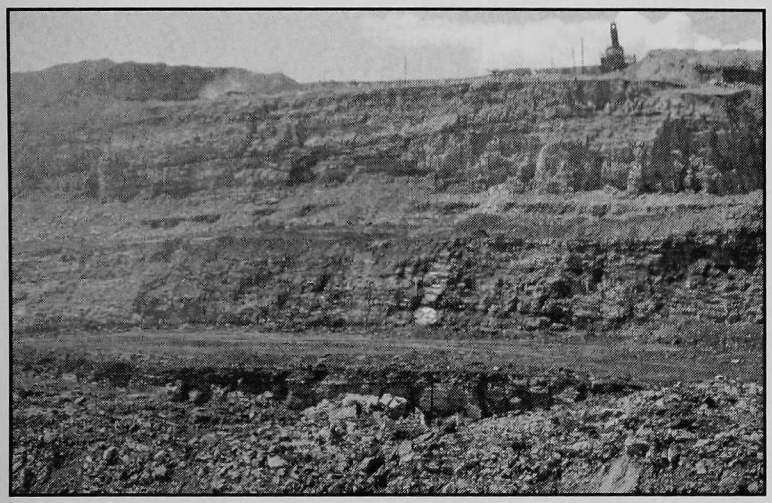


Figure 8. Colowyo's surface mine benching technique, Danforth Hills Coal Field, Moffat County.

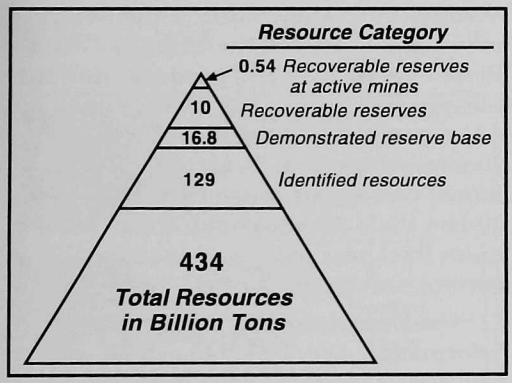


Figure 9. Colorado coal resources and reserves. (Source: DOE-EIA data, 1998)

Geological Survey (CGS) in the Somerset and Yampa Coal Fields significantly increases the EIA estimate of reserves.

The new demonstrated reserve figures calculated by the CGS are 6 billion tons for the Somerset Field and 9 billion tons for the Yampa Coal Field alone. These figures may increase the state's total demonstrated reserve to nearly 20 billion tons.

Recoverable reserves under lease at active mines were 540 millions tons in 1998. At the current production rate of 30 million tons per year, this gives a 19-year recoverable coal supply under lease at operating mines. New lease areas that were proposed by the coal operators in the Somerset Coal Field should revise these numbers upward in 2001. These are pending finalization of an Environmental Impact Statement in the North Fork Valley area of the Somerset Coal Field.

Coal Quality

Coal-bearing units underlie some 29,600 square miles or 28 percent of Colorado. According to the U.S. Geological Survey's COALQUAL database, coal produced in Colorado today is generally bituminous coal that is low in sulfur and trace elements such as mercury, with a moderately low ash content (Fig. 10). Colorado coal's value in terms of a salable coal product is that it complies with Federal environmental air emission regulations. Because of this Colorado coal is used extensively as blended compliance coal in power plants in other states.

Coal resources range in rank from lignite in the Denver Basin to anthracite near Crested Butte, Gunnison County. Colorado's produced coal averages 11,131 Btu/lb—ranging from 9,850 to 13,100 Btu/lb. Ninety percent of the coal mined in 1999 was bituminous; the remainder was subbituminous. Much of the mined Colorado coal is clean enough to burn without washing, although six coal mines have preparation plants on site (Table 4). These plants are used infrequently and accordingly much of the production from these mines is shipped directly without washing. One prep plant at the Roadside Mine in Mesa County was recently dismantled. Although some of the mined coal is of coking quality, current production is exclusively used as steam coal. Low-sulfur Colorado coal is mixed with higher-sulfur coals in other states to reduce

Table 4. Coal preparation plants in Colorado. (Source: *2000 Keystone Coal Industry Manual*)

Company	Prep Plant	Location	Tons Per Hour	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	—	—
Powderhorn Coal	Roadside*	Palisade	400	1978

*dismantled 2000

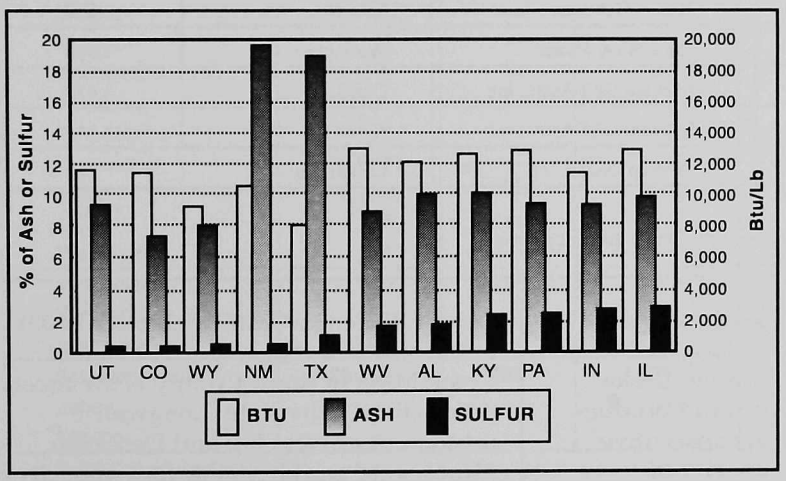


Figure 10. Quality comparison of coal produced in Colorado and selected states.

power plant emissions. This is reflected in coal sales for the last decade; Colorado coal production has increased from 17.7 million tons in 1991 to 29.9 million tons last year. Future use of Colorado coal for environmental compliance with the Clean Air Act (1990) is assured at power plants for some time to come.

Consumption and Distribution

According to the EIA in 1998, 20.1 million tons of coal were delivered to various users in Colorado (Fig. 11). Of this total, 19.4 million tons were transported to electric utility plants within the state. Coal burned at Colorado power plants comes exclusively from within the state (11.4 million tons in 1998) and Wyoming (8.0 million tons). Other users include small industrial plants that consumed 681,000 tons of mostly Colorado coal in 1998, and residential and commercial sectors that only used 18,000 tons. This latter sector uses mostly Colorado coal but a small amount is imported from Utah as well according to EIA. Colorado imported 18,000 tons of anthracite from Pennsylvania (perhaps for blacksmithing) and 11,000 tons of coal from New Mexico in 1998 for industrial plant (non-coke) usage. Less than half of the coal produced in Colorado is used within the state (Fig. 11). Of the 12 million tons of Colorado coal produced and used locally,

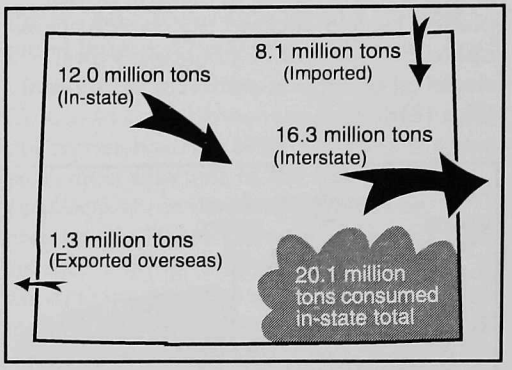


Figure 11. Colorado coal consumption diagram, 1998 data.

95 percent was used at electric power plants (Table 5) around the state. Approximately 82 percent of Colorado's total electrical energy output is fueled by coal (Fig. 12).

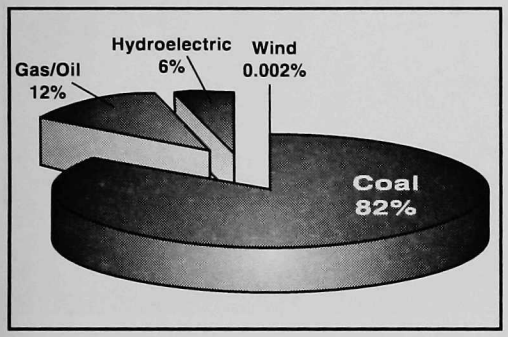


Figure 12. Estimated electricity generated by fuel type at Colorado power plants, 1999.

Of the 29.6 million tons of coal produced in Colorado in 1998, the majority was distributed to other states and foreign countries. Colorado shipped coal by railroad, truck, and eventually even river traffic to 21 other states in 1998 (Fig. 13 and Table 6). Texas, Illinois, Utah, and Tennessee were the largest consumers of Colorado coal. Foreign exports account for about 6 percent of Colorado's coal distribution as 1.332 million tons were shipped to Mexico and 422,000 tons were shipped to Japan in 1998.

Productivity and Capacity

The large underground coal mines in the state have increased coal production and productivity by use of more efficient technology such as longwall mining. Colorado longwall mines broke state and world underground production records for the fifth consecutive year. The productive capacity of Colorado's coal mines is calculated at 36,658,000 tons (EIA, 1998), which is about 6.7 million tons greater than the 1998 production levels.

A total of six longwall operations were counted in *Coal Age* magazine's Longwall Census' 2000 (February 2000) in Colorado. A longwall at the Foidel Creek Mine in Routt County is the most productive in the state. Longwall machinery at West Elk and Deserado Mines were working at or near capacity in 1999. One new longwall at Sanborn Creek Mine was down for five months due to a mine fire in 1999. The Empire Mine longwall is counted in their census but has been idle since 1995. A new longwall at the Bowie No. 2 Mine has

Table 5. Consumption of coal at electric generation plants in Colorado, 1998. See Figure 6 for generation plant locations.

Map No.	Plant	Utility	Location	1998 Consumption (thou. tons)
1	Drake	Colorado Springs	Colorado Springs	777
2	Nixon	Colorado Springs	Colorado Springs	745
3	Arapahoe	PSC† of Colorado	Denver	697
4	Cameo	PSC of Colorado	Cameo	298
5	Cherokee	PSC of Colorado	Denver	2,201
6	Comanche	PSC of Colorado	Pueblo	2,732
7	Hayden	PSC of Colorado	Hayden	1,543
8	Pawnee	PSC of Colorado	Brush	2,104
9	Valmont	PSC of Colorado	Boulder	592
10	Rawhide	Platte River Power	Wellington	1,050
11	Craig*	Tri-State G&T Assn., Inc.	Craig	4,478
12	Nucla*	Tri-State G&T Assn., Inc.	Nucla	315
13	Clark*	Utilicorp United, Inc.	Canon City	129
Total				**17,661**

*Based on data for coal received during 1997, †Public Service Company

Table 6. Distribution of coal produced in Colorado, 1998 All figures in thousands of tons.

State of Destination	Electric Utilities	Coke Plants	Industrial Plants	Residential-Commercial	Total
Alabama	427	—	—	—	427
Arizona	355	—	112	—	467
Arkansas	5	—	—	—	5
California	—	—	78	—	78
Colorado (in-state)	11,435	—	543	14	11,992
Illinois	2,234	—	199	—	2,433
Indiana	—	51	—	—	51
Iowa	471	—	124	—	595
Kansas	1,289	—	—	—	1,289
Kentucky	1,962	—	—	—	1,962
Michigan	33	—	143	—	176
Missouri	14	—	—	—	14
Montana	6	—	—	—	6
Nebraska	6	—	91	—	97
Nevada	20	—	—	—	20
New Mexico	57	—	73	—	130
Tennessee	2,064	—	—	—	2,064
Texas	3,189	—	120	—	3,309
Utah	1,797	441	—	—	2,238
Washington	4	—	3	—	7
Wisconsin	20	—	—	—	20
Wyoming	—	—	149	—	149
Unknown	11?	—	—	—	11
Total domestic	**25,388**	**492**	**1,635**	**14**	**27,540**
Japan	—	—	—	—	422
Mexico	—	—	—	—	1,332
Total Colorado Coal					**29,294***

*EIA estimate for 1998

been operational since November 1999. This machine doubles now Bowie's capacity. The longwall systems (Fig. 14) operating in Colorado last year had panel widths ranging from 580 to 950 feet, panel lengths from 4,000 to 17,600 feet, and cutting heights from 102 to 144 inches (Table 7). The West Elk Mine has the tallest cutting height for a longwall shearer in the country (144 inches) and the Foidel Creek Mine has the longest panel length, 17,600 feet, in the country.

According to EIA, productivity of Colorado coal mines was 8.47 short tons per miner-hour in 1998, which is the seventh most efficient in the nation. This productivity is divided into underground (8.27 tons per worker hour) and surface mining (8.89 tons per worker hour) (Fig. 15). This underground figure is the second highest in the country and is attributed to the efficient longwall machines that operate in long, thick, continuous Colorado coal seams.

Coal Age magazine predicts that the year 2000 will show stable numbers of longwall systems and increased production (as the longwall equipment becomes more reliable, coal availability and capacity should grow). Automated systems such as shearer-initiated shield advance and in-seam guidance systems will be the future technological improvements.

News and Developments

An Environmental Impact Statement (EIS) conducted by the U.S. Forest Service and the Bureau of Land Management in the North Fork Valley was the big news in Colorado coal for 1999. The EIS was prompted when mine plans developed by the North Fork Valley mine operators disclosed plans to increase coal production threefold in the valley during the next five years. A draft plan was submitted in October 1999 for review and public comment. The EIS

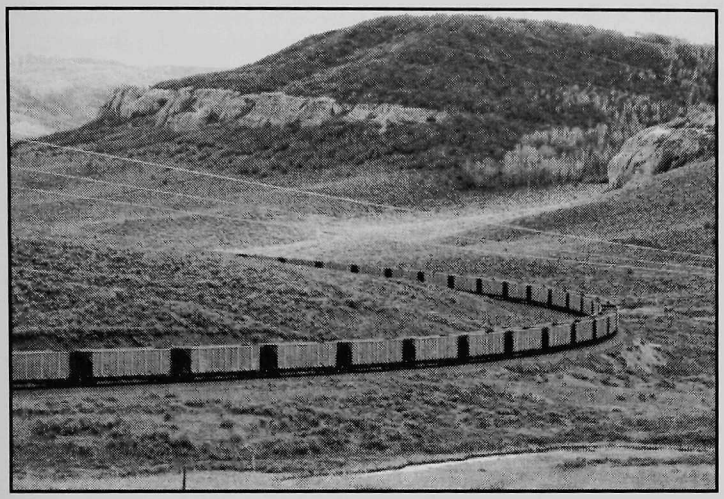


Figure 13. Coal train loading at Foidel Creek (Twentymile) Mine, Routt County.

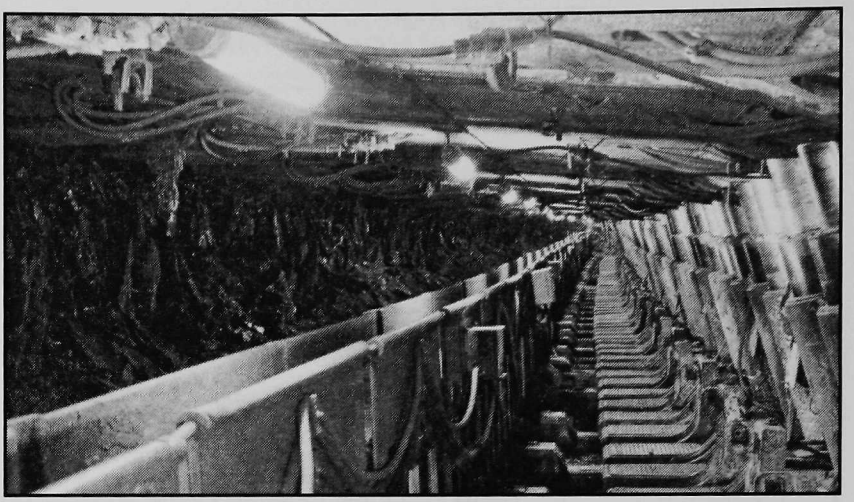


Figure 14. Longwall operation at the Foidel Creek (Twentymile) Mine, Routt County.

hopes to identify and evaluate specific impacts of future coal development near the Bowie No. 2 and Sanborn Creek Mines. A ruling on the EIS is expected in March 2000 and a decision on Bowie Resources and Oxbow Mining's lease sales may follow shortly thereafter. Oxbow Mining Inc. is particularly hopeful that the EIS will be completed and favorable for lease sales by the end of May 2000. In Paonia, the North Fork Coal Working Group was formed and consists of coal, environmental, agricultural, community, and local government representatives. This organization was formed to discuss the issues related to growth of coal mining in the valley. The main goal of the group was to address the concerns of coal development in a positive and cooperative manner. Several meetings were held in 1999, some as heated discussions, but most were productive. This group continues to meet and discuss and arbitrate conflict in the community. Development work to support a longwall operation for Bowie Resources has been finalized and is online. Bowie is active in the North Fork Group with consensus from local citizen concerns. More frequent rail service to the area should help Bowie increase production to its 5 million-ton goal in the next few years.

All twelve active coal mines operated nearly continuously throughout 1999. The only notable exceptions were 5 months of lost production at Sanborn Creek due to a mine fire, and a one-month stoppage at Deserado due to a labor strike. A slowdown of operations at both King Coal and Roadside Mines occurred at the end of the year, and Roadside operated until Dec. 31 when it closed. Despite these setbacks, Colorado coal production was still at an all-time level.

Sanborn Creek's target of 4 million tons annual production with its new longwall equipment came to an abrupt halt when sensors behind the wall indicated a spontaneous combustion event in January 1999. No injuries were reported, and by May, the mine was operating at a somewhat reduced capac-

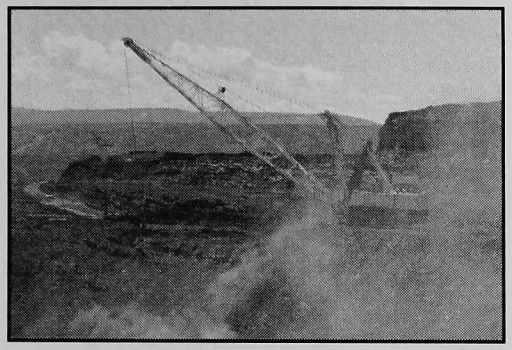


Figure 15. Dragline operation at Colowyo Coal Mine, Moffat County.

ity. It was determined that a fire had occurred in an underground shop area, and explosions from spontaneous combustion had occurred near the new longwall unit but did not damage the machine. The unit was moved to the east end of the mine and no operational problems exist now. The longwall was back in full operation by November 1999. One panel of the mine plan was used as a barrier to the spontaneous combustion area in the east part of the mine. Sanborn Creek has had no recurrence of spontaneous combustion since then. The mine increased production and produced one million tons by year's end. The rail system to the North Fork Valley is still operationally below capacity, but stockpiles are low at Sanborn Creek, Bowie No. 2, and the West Elk mines so production is not stymied for now. The 20-foot thick B seam is currently the only productive zone at West Elk. They hope to mine the 13-foot E seam in the future, which would be an additional 100 million tons of 11,700+ Btu/lb coal.

A spontaneous combustion event recently occurred at the West Elk Mine as well. Detection of elevated carbon monoxide levels in the mine in late January 2000 prompted West Elk officials to evacuate the mine. West Elk and MSHA officials are drilling to analyze gas samples to determine where the carbon monoxide leak is located. Miners are on leave while the mine is idle. Officials recently isolated the event to a collapse zone behind an active longwall face. They hope to seal off the area from the active mining zone so that production can resume. Water from a reservoir will be used to cool the spontaneous combustion event in West Elk.

The most significant coal business news in northwestern Colorado was the purchase of Cyprus Amax Minerals coal division by RAG International Mining. RAG American Coal Co. now operates the Foidel Creek (Twentymile) coal mine in Routt County and the idle Empire Mine in Moffat County. The transaction value was $1.1 billion. RAG is a German multinational company with coal sales worldwide. RAG plans to phase out the

Table 7. Colorado longwall statistics (Source: *Coal Age Magazine*, February 2000)

Mine and Company	Seam	Seam Height (in.)	Cutting Height (ft)	Panel Width (ft)	Panel Length (ft)	Overburden Thickness (ft)	Depth of Cut (in.)	Shearer	Capacity (raw tons per shift)
Bowie Resources (Bowie Mine No. 2)	D	108–180	120	845	7,000	800–1,400	36	Long-Airdox DDR EL 1,030	
Deserado (Blue Mtn.)	D	96–102	96–102	800	6,000	1,600–2,100	30	Joy 4LS DDR 1,030	8,000
Empire (RAG American Coal)	E	126–138	120	750	7,500	600–1,200	36	Long-Airdox DDR 1,200	
Sanborn Creek (Oxbow Mining)	B	180	132	580	4,000	1,500–2,500	30	Joy 4LS DDR 1,030	8,000
Twentymile (RAG American Coal)	Wadge	96–114	102	840	17,600	600–1,300	36	Long-Airdox DDR	1,920
West Elk (Mt. Coal)	B	276	144	950	3,500–9,000	600–1,400	40	Joy 6LS DDR 1,720	15,000

Denver office and move operations to Baltimore, MD. Mining activities will essentially remain the same, with Foidel Creek Mine continuing to operate at maximum capacity but with fewer miners. Twenty-six miners were laid off at the end of the year. The mine made two longwall moves last year, and despite this, the mine still surpassed state production records. Twentymile sells to the Asian Rim and Mexico as well.

No faults or steeply dipping structures affect the longwall now. No longwall mining is planned in the faulted area and RAG plans to mine coal in the Twentymile Park area for several years to come.

Trapper Mine is using Global Positioning System detectors on two cutting machines to increase efficiency for cut slopes on coal seams. Trapper has an ash management reclamation plan in-place with its mine-mouth customer, the Tri-State power plant. Coal ash is hauled from the power station back to the Trapper Mine where it is used as fill to re-contour its reclamation pit to natural grades. Seneca Coal Company increased its permit size by adding 1,416 acres to the south of its current operation.

In news from the smaller coal mines, the long range outlook is not as bright. The Southfield Mine near Canon City reports being nearly out of reserves of salable low sulfur coal. The state's smallest coal mine now has a resource of less than one million tons. Sales in southwestern Colorado have also slumped as the King Coal Mine (Fig. 16) near Durango released 25 employees in 1999. Most of their coal is sold to cement processors and less to electric generation plants. Without rail service and long-term contracts King Coal cut production by fifty percent. The Roadside Mine in Mesa County shut down at the end of the year. The Peabody Holding Company decided to close the mine and send it to reclamation. The prep plant was dismantled and the portals will be sealed by April 2000. The McClane Canyon Mine in Mesa County reopened in March 2000 as a source for the Cameo power station.

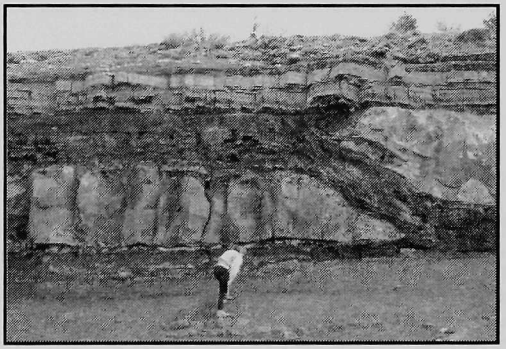


Figure 16. Complex coal strata, southwest Colorado.

Deserado coal mine moved their longwall last year to a new seam (B seam) without incident. A union strike in May 1999 concluded quickly. The rail-line hauling their production to the Bonanza power plant was washed out last summer by flash flooding in the Bookcliffs region. The line was reinstalled, but not before being down for six weeks in August and September. The Deserado Mine supplies coal to the Bonanza power plant in Utah.

Coal Outlook reported in February 2000 that 1999 was a year to be remembered as one that changed the face of the coal and utility industries. The EPA lawsuit against the coal-fired utilities in the east, the uncertainty over environmental issues such as fine particulate matter ($PM_{2.5}$) and ground ozone standards and new requirements for NO_x reductions for selected power plants, raised the level of risk at coal-fired electrical stations.

Nationally, coal production was down by 10 million tons due to mild fall weather and improved nuclear power plant performance in the Midwest. The potential for natural gas to supplant coal at power plants is growing because of economic factors in coal delivery and the growing environmental pressures to reduce SO_2, NO_x, and $PM_{2.5}$ emissions.

Railroad service limitations, in part caused by the merger of the Union Pacific and Southern Pacific railroads, have, for the most part, been resolved in 1999. Rail traffic to the Somerset Coal Field would increase substantially if the three mines there get permission to expand.

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 $4 to $5 per ton range. As the coal spot market price and volume lowers, coal companies are under pressure to exceed capacity and produce volumetrically more coal with less personnel. Passage of severance tax relief legislation in 1999 has helped the large Colorado coal companies to produce coal more profitably.

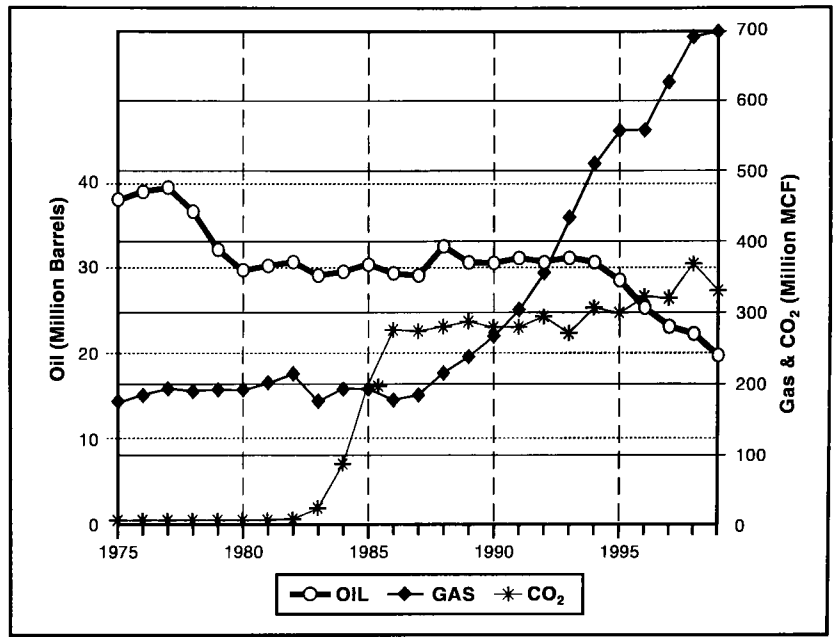


Figure 17. Colorado annual oil, natural gas, and carbon dioxide production, 1975–1999. Note general rise in natural gas production and steeping decline in oil production.

OIL AND GAS

Production

Colorado hydrocarbon production in 1998 totaled nearly 22.5 million barrels of oil (MMbo) and 705 billion cubic feet (bcf) of natural gas. Carbon dioxide production totaled almost 368 bcf. In 1998, Colorado ranked 10th of all states in daily crude oil and lease condensate production with 61,531 barrels of oil (bo) per day and 6th in daily dry gas production with 1.93 bcf per day. Consumption of natural gas in the state in 1998 totaled 312 bcf. Accordingly, Colorado consumed 44.3 percent of its produced natural gas volume.

Extrapolation of as yet incomplete 1999 hydrocarbon and carbon dioxide production volumes compiled by the Colorado Oil and Gas Conservation Commission (COGCC) suggest the state's full year production figures will be 19.7 MMbo, 700 bcf of natural gas, and 330 bcf of carbon dioxide. The projected 1999 oil volume of 19.7 MMbo is a 12.4 percent decline from 1998 and represents a continuing decline in Colorado oil production that began in 1977 when the state's annual production stood at 39.5 MMbo. The projected 1999 annual volume of 700 bcf of natural gas production would end a 12 year long trend of climbing Colorado natural gas production. The projected 1999 annual volume of 330 bcf of carbon dioxide production would represent a 10.3 percent decline from the annual state production record established for this commodity in 1998 (Fig.17).

The Energy Information Administration (EIA), an independent statistical and analytical agency within the U.S. Department of Energy estimated that dry natural gas production in the U.S. during 1998 totaled 18,720 bcf, down some 3 percent from 1997. The Gulf of Mexico Federal Offshore and the State of Texas in 1998 were the nation's leading producers of dry natural gas with volumes respectively of 4,872 bcf and 4,855 bcf. These two regional subdi-

visions accounted for 52 .0 percent of U.S. 1998 gas production volume. These same two regions in 1997 produced 5,133 bcf and 4,952 of natural gas, accounting for 52.5 percent of U. S. annual production.

In 1997, the southern Rocky Mountain region of Colorado, northern New Mexico, Utah, and Wyoming accounted for 2,759 bcf of the nation's dry natural gas production according to EIA data. This volume represented approximately 14.4 percent of the country's 1997 annual production. During 1998 the southern Rocky Mountain natural gas production contribution was flat with the previous year's regional production. The overall decline in the nation's consumption of natural gas in 1998 was due in large part to nearly nation-wide milder average winter and summer temperatures. Nonetheless, the percent of southern Rocky Mountain region natural gas production grew to a 14.7 percent contribution in 1998. From a state perspective, Colorado accounted for 3.4 percent of U.S. natural gas production in 1997 and 3.8 percent of U.S. natural gas production in 1998.

Natural gas production in the southern Rocky Mountain region in 1987 totaled 1,021 bcf. Since then regional volumes have risen every year until the 1998 regional volume of 2,759 bcf came in level to the 1997 volume. As a percentage of regional production, Colorado's natural gas production has risen in the same time period from 15.6 percent to 25.6 percent. An indication of Colorado's growing importance to the national energy equation as a source of clean burning natural gas is the fact that Colorado, for the first time in 1991, became a net exporter of natural gas, shipping approximately 21 bcf out of state. Because of the state's steadily rising natural gas production, this volume has increased in 1998 approximately nineteen-fold to 393 bcf.

Colorado coal bed methane production in 1998 totaled 387 bcf, which placed Colorado in second place in the U.S. behind New Mexico's 571 bcf. This "new" record volume of coalbed methane production represents 54.5 percent of the state's total gas production. The incomplete 1999 Colorado production figures available at the time of this writing in March 2000 suggest that coal bed methane annual production in 1999 will be flat with 1998 volumes; the first time in over 10 years this component of the state's energy mix has not increased.

In 1998, Rio Blanco County led all Colorado counties in oil production (Table 8). The Rangely field's Weber Sandstone pool (Permian and Pennsylvanian age) produced 6,941,775 bo, which provided 92.5 percent of the county total. Second and third place in county oil production went to Weld County and Cheyenne County. Wattenberg's Muddy (J) Sandstone, Codell Sandstone, Niobrara Formation Chalk, Sussex Sandstone, and Shannon Sandstone reservoirs, all Cretaceous in age, were the major contributors in Weld County, accounting for 73.0 percent of the county oil production.

Table 8. Top three oil producing counties in Colorado in 1998 (BO = barrels of oil).

Rating	County	Annual Oil Prod., BO	Cum. Oil Prod., BO
1	Rio Blanco	7,504,600	928,828,021
2	Weld	7,128,654	184,253,232
3	Cheyenne	3,174,825	74,242,182

The top three natural gas producing counties in 1998 were La Plata, Weld, and Garfield (Table 9). La Plata County's Ignacio Blanco field's Fruitland Formation coalbed methane reservoir (Late Cretaceous age) contributed 359.3 bcf (91 percent) of La Plata County's natural gas production. Wattenburg field provided just over 89 percent of the Weld County natural gas total. Colorado achieved a significant milestone in October 1998 by exceeding 10 trillion cubic feet of cumulative natural gas production.

Table 9. Top three natural gas producing counties in Colorado in 1998 (Mcf = thousand cubic feet).

Rating	County	Annual Gas Prod., Mcf	Cum. Gas Prod., Mcf
1	La Plata	394,645,144	3,003,942,189
2	Weld	113,749,870	2,014,277,554
3	Garfield	59,285,662	404,358,918

The producing well count for the state in 1998 was 17,454. The break down by category was 40 carbon dioxide producers, 1,335 coalbed methane producers, and 16,079 conventional oil and gas wells. Weld County led all counties in number of active wells with a total of 8,434.

Consumption

State natural gas consumption by sector in 1998 is listed below in Table 10.

Table 10. 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**

Over 99.5 percent of Colorado carbon dioxide production is shipped via pipeline to west Texas to optimize enhanced oil recovery from selected heavy oil reservoirs in the Permian Basin.

State consumption of refined oil for 1997 is listed below in Table 11. Data for 1998 from the EIA is not available at the time of this publication.

Table 11. 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**

Colorado crude oil production in 1997 totaled 24,369,131 barrels. In contrast, consumption of refined crude oil products in Colorado during 1997 was almost three times the state's oil production. Perhaps most telling is the fact that motor gasoline consumption in the state in 1997 was nearly twice the state's crude oil production. Also, of note is the fact that in 1997 U.S. gasoline consumption totaled 2.926 billion barrels compared to a national total of 2.138 billion barrels of crude oil production in the same time period.

Value and Pricing

The total production value in 1999 for oil, gas and dioxide production in Colorado estimated at $1,913 million dollars: oil $326 million, natural gas $1,504 million, and carbon dioxide $83 million. The total production value in 1998 for these same commodities in Colorado was $1,745 million dollars: oil $285 million, natural gas $1,375 million, and carbon dioxide $85 million. The 1999 anticipated rise in production value of $168 million as compared to 1998 was a result primarily of higher wellhead gas prices coupled with only a minor reduction in annual 1999 production volumes as compared to 1998 volumes. Figure 18 shows the Colorado oil and gas monthly wellhead price index for 1997 through 1999.

The average annual wellhead price in Colorado for oil increased by nearly 31 percent from $12.65 per bo in 1998 to $16.54 per bo in 1999. The average wellhead price for gas in the state increased by almost 12 percent from $1.95 per Mcf in 1998 to $2.12 per Mcf in 1999. The wellhead price for carbon dioxide increased slightly from $0.23 per Mcf in 1998 to $0.25 per Mcf in 1999. Figure 19 shows 1999 estimated annual Colorado oil, natural gas, and carbon dioxide production values for individual counties. Ten of Colorado's 63 counties generated over $30 million in production value of oil and/or gas.

Drilling Permits and Drilling Activity

In 1999, 1,096 permits were processed by the COGCC (1,010 drilling and 86 re-completion). This compares to 1,310 drilling permits and 153 re-completion

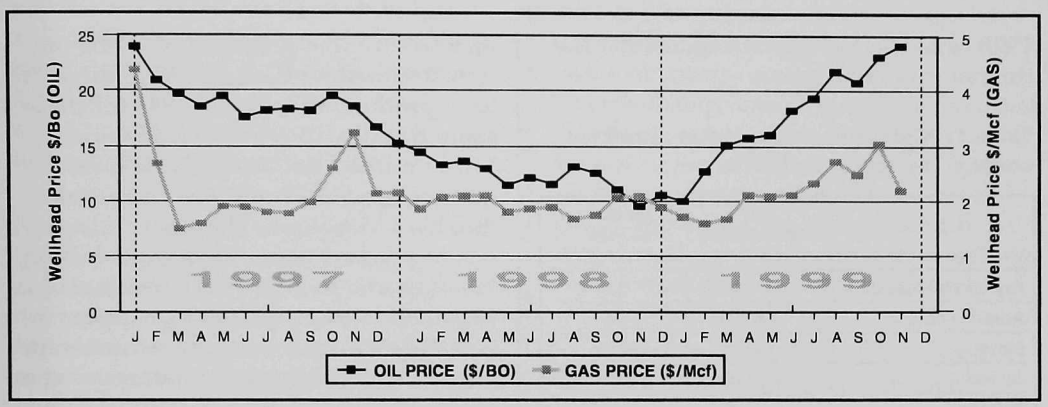


Figure 18. Colorado oil and gas monthly wellhead price index 1997 through 1999. (Data from Colorado Oil and Gas Conservation Commission files)

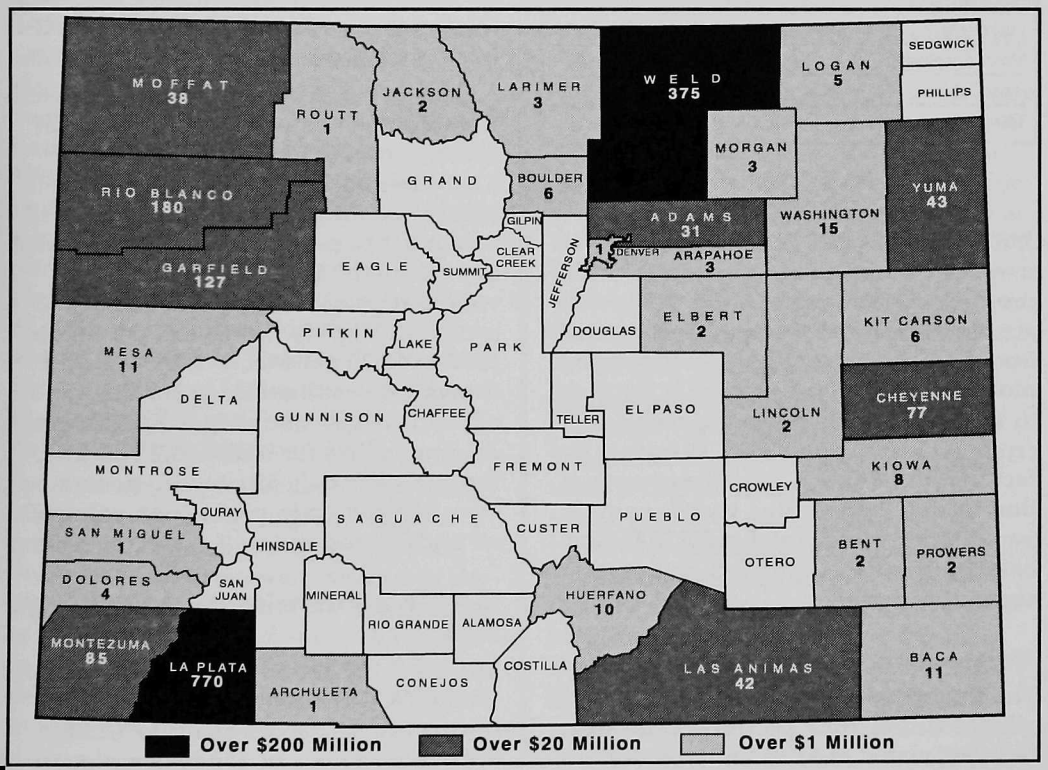


Figure 19. Estimated Colorado county oil and gas production values, 1999 (in millions of dollars). (Data from Colorado Oil and Gas Conservation Commission files)

permits processed in 1998. The five counties that led in 1999 permit applications were Weld (340), Las Animas (195), Garfield (131), La Plata (118), and Rio Blanco (100). Weld County also led in 1998. Garfield County moved from fourth place to third place in 1999 as a result of accelerated development of the Mesaverde Group Williams Fork natural gas sandstone reservoir in the Rulison, Parachute, and Grand Valley field areas west of Rifle. Rio Blanco County rose from sixth to fifth place in 1999 as a result of accelerated development of the Mancos "B" sandstone reservoir on the Douglas Creek Arch in the greater Dragon Trail field area. Las Animas County activity was driven by expanding development of the Vermejo Formation coalbed methane reservoir in the central Raton Basin (Fig. 20).

A group of gas producers led by BP-Amoco in January 2000 filed a joint application to drill an additional 560 in-fill coal bed methane wells in Rio

Blanco County. Barrett Resources, Inc., also in January 2000, filed an application for 20 acre spacing for the Williams Fork Formation on roughly 9,000 acres of its 160,000 acres in western Garfield County. Currently the spacing for this reservoir is one well per 40 acres. Approval by the COGCC of these filings will result in both La Plata and Garfield counties continuing their statewide leadership in drilling activity for at least the next two or three years.

Daily rig counts in Colorado were down slightly in 1999 to an average of 12.58 from 12.75 in 1998. By contrast, the daily average of rotary rigs working in the U.S. (land, inland waters, and offshore), was off 29.8 percent in 1999 as compared to 1998 (837 vs. 583). Exclusive of federal offshore, Colorado was in sixth place among the states in average daily drilling activity during 1999. The five states that led Colorado in drilling were Texas (284 units), Oklahoma (81 units), Louisiana (65 units), New Mexico (43 units) and Wyoming (36 units).

Table 12 is the final list of Colorado oil and gas field wildcat discoveries in 1998 derived from COGCC files. Figure 21 locates these wells in map view. COGCC had not yet compiled the list of wildcat discoveries for 1999 at the time of this writing.

Reserves

Proven crude oil reserves in Colorado at the end of 1998 were 212 MMbo, up from 198 MMbo at the end of 1997.

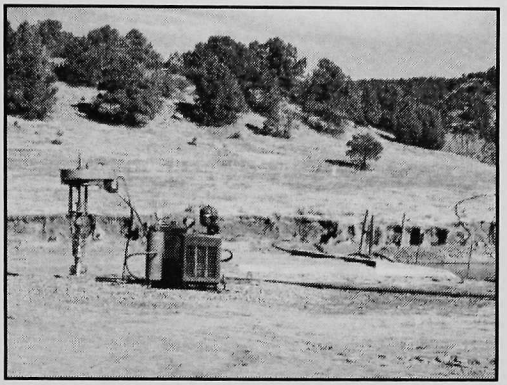


Figure 20. Evergreen Resources well in the rapidly growing Spanish Peak coalbed methane field in the central Raton Basin area. The Lazy Lizard 11-4 was completed in May 1997 from Vermejo Formation coal seam perforations at 790 to 978 feet at an initial flow rate of 412 thousand cubic feet of gas per day. At the end of December 1999, the Lazy Lizard was flowing at 488 thousand cubic feet of gas a day with a cumulative production total of 370 million cubic feet of gas.

Proven dry natural gas reserves in Colorado at the end of 1998 were 7,881 bcf, up from the 1997 total of 6,828 bcf.

The U.S. had 21,034 MMbo of crude oil proved reserves as of December 31, 1998. This is 7 percent (-1,512 MMbo) less than in 1997, and is the largest percentage decline in oil reserves in 53 years. Four areas account for 79 percent of U.S. crude oil reserves: Alaska 24 percent (5,052 MMbo), Texas 23 percent (4,927 MMbo), California 18 percent (3,843 MMbo), and Gulf of Mexico Federal Offshore 13 percent (2,793 MMbo). Of these four areas, only California was able to increase reserves in 1998. Colorado's percentage of the nation's proved crude oil reserves at the end of 1998, by way of perspective, was just over 1 percent. The 1998 figures put Colorado in tenth place among the 50 states (excluding Federal Offshore) in crude reserves up from eleventh place in 1997 (Table 13).

The nation's 1998 proved reserves of dry natural gas were 164,041 bcf, 2 percent less than in 1997. The four-year trend of increasing U.S. dry natural gas proved reserves came to an end in 1998. Additions to dry gas reserves in 1998 were down 22 percent compared to 1997 (15,538 bcf vs. 19,960 bcf). Five areas account for 64 percent of U.S. dry natural gas proved reserves: Texas 23 percent, Gulf of Mexico Offshore 16 percent, New Mexico 9 percent, Wyoming 8 percent, and Oklahoma 8 percent. Colorado's percentage of U.S. dry gas reserves at the end of 1998 was 4.8 percent. Colorado was in seventh place among the states in proved dry natural gas reserves (Table 14). Clearly Colorado's gas component of hydrocarbon reserves plays a much more significant role in the nation's energy equation than does the state's liquid component.

Colorado's net increase of 1,053 bcf was the largest net gas reserve increase of all states in 1998, derived mostly from

Table 12. New oil and gas fields discovered in 1998. See map in Fig. 21.

Map No.	Field Name	Sec.	Twp.	Rge.	PM	County	Pay Zone	Initial Potential		
1	Azetecan	4	17S	45W	6	Kiowa	Morrow	——	864 MCFGPD	14 BWPD
2	Baby Doe	22	4N	59W	6	Morgan	D Sandstone	2 BOPD	25 MCFGPD	
3	Bazooka	24	15S	45W	6	Cheyenne	Mississippian	25 BOPD	——	17 BWPD
4	Clear View	16	32S	66W	6	Las Animas	Vermejo	——	80 MCFGPD	148 BWPD
5	Feather Stone	13	11S	46W	6	Kit Carson	Morrow	——	183 MCFGPD	2 BW
6	Fever Pitch	17	12S	44W	6	Cheyenne	Morrow	5 BOPD	946 MCFGPD	31 BWPD
7	Grande	18	32S	67W	6	Las Animas	Vermejo	——	41 MCFGPD	220 BWPD
8	Grande West	12	32S	68 W	6	Las Animas	Vermejo	——	43 MCFGPD	79 BWPD
9	Hammer Head	18	2S	51W	6	Washington	Muddy (J) Sandstone	40 BOPD ——	—— ——	360 BWPD ——
10	Ice	31	13S	46W	6	Cheyenne	Morrow	——	1685 MCFGPD	55 BWPD
11	Lathrop	36	28S	67W	6	Huerfano	Vermejo	——	Gas	Water
12	Little Creek	3	29S	67W	6	Huerfano	Vermejo	——	Gas	Water
13	Maxwell	3	18S	42W	6	Kiowa	Morrow	——	1738 MCFGPD	2 BWPD
14	Open View	36	9N	58W	6	Weld	D Sandstone	1 BOPD	50 MCFGPD	18 BWPD
15	Peacock	19	3N	62W	6	Weld	D Sandstone	200 BOPD	75 MCFGPD	——
16	Pennypacker	35	11S	45W	6	Kit Carson	Morrow	10 BOPD	1632 MCFGPD	33 BWPD
17	Shinnecock	8	17S	45W	6	Kiowa	Morrow	——	Gas	——
18	West Lightfoot	35	12N	57W	6	Weld	Muddy (J) Sandstone	11 BOPD ——	13 MCFGPD ——	80 BWPD ——
19	Wild Dove	33	24S	47W	6	Prowers	Morrow	——	188 MCFGPD	——
20	Wild Fox	6	14S	46W	6	Cheyenne	Morrow	5 BOPD	915 MCFGPD	27 BWPD

Abbreviations: BOPD—barrels of oil per day; BCPD—barrels of condensate per day; MCFGPD—thousands of cubic feet of gas per day; BWPD—barrels of water per day

net revisions. Development of existing fields in the Piceance and Denver Basin —mostly done through less expensive re-completions, rather than more expensive new wells-boosted the reserve additions in the state.

An important component of Colorado's proved natural gas reserve base is coalbed methane. Proved coalbed methane reserves are located principally in three states: New Mexico, Colorado, and Alabama. In 1998, reserves of

Table 13. Top ten oil producing states—proved reserves 12/31/98.

Ranking	State	Proved Crude Oil Reserves (Million Barrels)
1	Alaska	5,052
2	Texas	4,927
3	California	3,843
4	New Mexico	620
5	Oklahoma	599
6	Louisiana	551
7	Wyoming	547
8	Kansas	246
9	North Dakota	245
10	Colorado	212

Table 14. Top ten natural gas producing states—proved reserves 12/31/1998.

Ranking	State	Proved Dry Natural Gas Reserves (Bcf)
1	Texas	37,584
2	New Mexico	14,987
3	Wyoming	13,650
4	Oklahoma	13,645
5	Alaska	9,927
6	Louisiana	9,147
7	Colorado	7,881
8	Kansas	6,402
9	Alabama	4,604
10	Utah	2,388

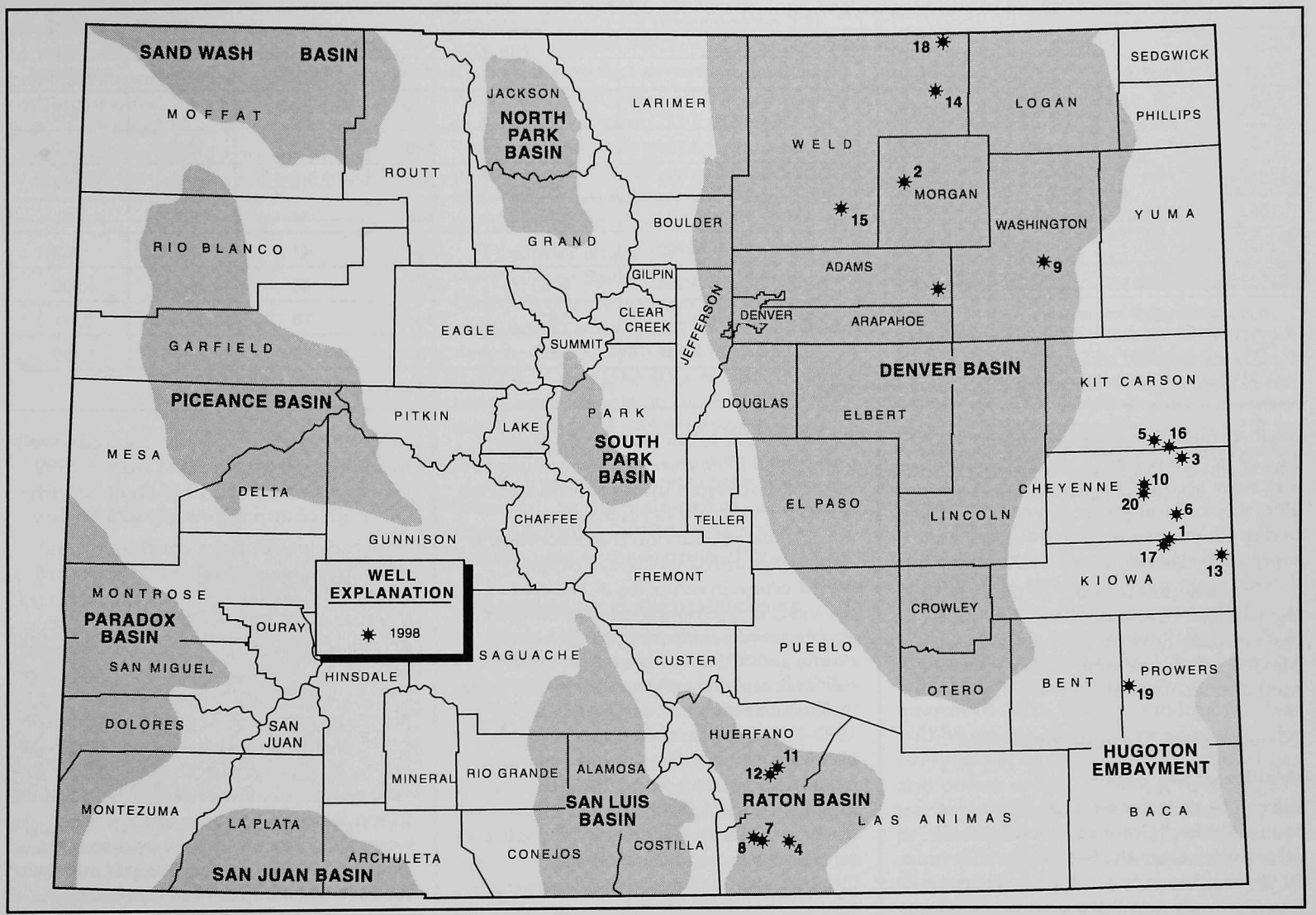


Figure 21. Location map of 1998 wildcat oil and gas discoveries in Colorado. See Table 12 for name, location, pay zone, and initial potential of the discoveries

Table 15. U. S. Coalbed methane proved reserves and production, 1991–1998 (billion cubic feet).

Year	Alabama		Colorado		New Mexico		Others*		Total	
	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production	Reserves	Production
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

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

coalbed methane increased 6 percent to 12,179 bcf from 1997's level (11,462 bcf) and now account for 7 percent of all 1998 dry natural gas reserves. U.S. coalbed methane production volumes have more than tripled since 1991 (Table 15).

Of particular interest in Table 15 is the fact that Colorado's coalbed methane reserve base now nearly equals New Mexico's, the long time leader in coalbed methane reserves and production.

News and Developments

Wellhead Oil Prices

When the year began, U.S., Rocky Mountain and Colorado wellhead oil prices were near the lowest level seen in 50 years when adjusted for inflation. The Colorado Oil Price Composite Index, as calculated by the COGCC, stood at $10.64/bo. These low prices going into 1999 were a continuation of a plunge that began in the second quarter of 1998. Driving this price fall was worldwide production that exceeded demand coupled with near capacity world crude inventories at the end of the year. Exacerbating the oversupply problems was a slowing in global economic growth and the fact that currencies and regimes in Southeast Asia were in financial disarray. In addition, the 1998-1999 winter in the Northern Hemisphere was, for energy sellers, frustratingly mild. To balance the market and strengthen crude prices, producers in March 1999 began to reduce output. By the end of June, the Organization of Petroleum Exporting Countries cartel and other producing nations cut production by about 3.2 MMbo/day. In response, Colorado wellhead oil prices have risen from a 1999 low in February of $10.04/bo to a year-end high of approximately $24.10/bo.

Crude prices have continued this rise into the end of the first quarter of 2000. This rise in wellhead crude prices has helped fuel a marked increase in drilling permit applications with the COGCC. COGCC reported the filing of 157 drilling permit applications in February 2000, the highest monthly total seen in Colorado within the last several years. The major part of this rise is driven by the coalbed methane play in the Raton Basin in western Las Animas County. However, there has also been a significant rise in permit applications in the oil prone Denver Basin, clearly in response to the rise in the wellhead price of Colorado crude oil (Fig. 22, 23).

In-fill Drilling

In 1999, the rise in both oil and natural gas prices stimulated additional in-fill drilling, a trend which is continuing into 2000. In the San Juan Basin, the Upper Cretaceous Fruitland Formation coals were originally developed on 640-acre spacing. Pilot in-fill programs on 320-acre and scattered 160-spacing units demonstrated that the existing well bores could not drain all the gas reserves in a 640-acre section. The discovery of virgin (original) or near-virgin reservoir pressure in both 320-acre and 160-acre in-fill wells paved the way for more economic in-fill drilling.

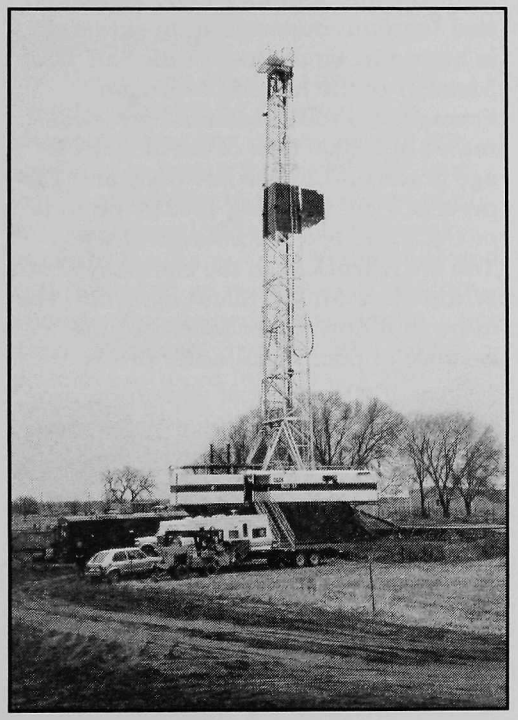


Figure 22. Caza Drilling Company Rig 17 on location in southwestern Weld County, April 2000. This H.S. Resources Incorporated well is scheduled as a 7,800 foot Muddy (J) Sandstone development well on the western edge on the Denver Basin's giant Wattenberg gas field.

A similar situation has occurred in the Piceance Basin. Here, the Mesaverde Group Williams Fork sandstone reservoirs are so aerially discontinuous that despite their overall thickness of 3,000 to 3,500 ft, it will take 40-acre, and in some cases, even 20-acre in-fill wells to efficiently drain the gas reserves in a 160-acre spacing unit.

With stable gas prices both of these areas will be the main drivers in the continued building of Colorado's gas reserve base and gas production stream.

Mergers and Acquisitions

Corporate mergers is one of energy company corporate strategies that has developed in recent years to boost profitability. Witness last year's merger of Exxon and Mobil and Amoco and British Petroleum Company. Recently caught up in this continuing trend are three corporations that have substantial operations in Colorado. Coastal Corporation, which operates several producing properties on the Douglas Creek Arch in addition to the Colorado Interstate Gas pipeline system and a substantial number of retail gasoline stations in Colorado, has executed definitive agreements for merger with El Paso Energy Corporation. The merger of these two Houston-based companies is a transaction valued at $16 billion. It is expected that the merger will be completed during the fourth quarter of 2000. With this merger El Paso will be among the top five companies in every sector of the wholesale natural gas and power arena, including natural gas transmission, production, gathering and processing, marketing, and power generation. The combined interstate transmission system of the new company will consist of over 58,000 miles of pipeline reaching all the major growth areas in the country, accessing every key supply

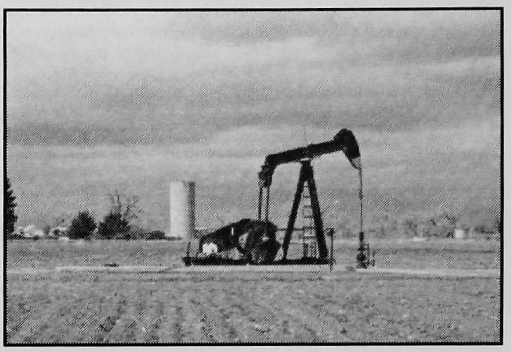


Figure 23. H.S. Resources Incorporated Sussex Sandstone oil producer in the Denver Basin's Spindle field. The John Henry Stolz Jr. "B" No. 1, located in the SW 1/4, NW1/4, sec. 24, T.1 N., R. 67 W., Weld County, was completed in 1970 from perforations at 4,702 to 4, 734 feet. The well's cumulative production at the end of 1999 was 58,643 barrels of oil and 125.6 million cubic feet of gas.

source in North America, and moving more gas than any energy company in the world.

Phillips Petroleum Company and Duke Energy Corporation recently signed definitive agreements to combine Duke's gas gathering and processing businesses and Phillips' gas processing and marketing unit to form a new midstream company to be called Duke Energy Field Services (DEFS). The new company, which will be based in Denver, will become the nation's largest midstream natural gas liquids business and the prime gatherer and processor of natural gas in the U.S. with an expected enterprise value of between $ 5 billion and $6 billion. The new company will have a strong position in most of the significant hydrocarbon basins in the U.S. At closing, Duke will own about 70 percent of the new company and Phillips will own 30 percent. The new company will operate 67 gas plants and 57,000 miles of pipeline, and have an estimated 17 trillion cubic feet of contracted supply. It will process approximately 5 bcf daily of raw gas, and produce 400,000 barrels daily of natural gas liquids. Prior to this business agreement Duke operated 52 plants in Wyoming, Colorado, Kansas, Oklahoma, New Mexico, Texas, and Alberta. One of these units is the Ladder Creek Helium Plant located on the outskirts of Cheyenne Wells, Colorado.

URANIUM AND VANADIUM

Prices for uranium oxide rose from a low of $7 per pound in the early 1990s to over $15 per pound in early 1997; however since then prices for uranium oxide have settled in the $9 to $10 range. According to the U.S. Geological Survey Mineral Information Office, the average price for vanadium oxide in 1999 was $2 per pound, down substantially from $5.47 in 1998.

Cotter Corporation's Schwartzwalder Mine produced about 400,000 pounds of uranium oxide in 1999. The mine is expected to close permanently by the end of March 2000 ending a long history of uranium production. The uranium deposit at the Schwartzwalder Mine was discovered in the mid-1940s and is located just a few miles north of Golden in Jefferson County. Uranium mineralization, primarily as pitchblende, occurs within steeply dipping hydrothermal veins injected into a Precambrian garnet-biotite gneiss and quartzite unit.

In February 2000, General Atomics of San Diego announced that it would purchase Cotter Corporation from Commonwealth Edison Co. of Chicago. Cotter Corporation will continue to operate its newly refurbished uranium mill in Canon City. They have been processing ore stockpiled from the Schwartzwalder Mine and other private and government stockpiles. The company plans to continue operating the mill utilizing stockpiles from various sources as feedstock.

International Uranium Corporation began production at the Sunday Mine complex in the Big Gypsum Valley, San Miguel County in July 1997. Vanadium and uranium mineralization at this site is hosted in sandstones of the Salt Wash Member of the Jurassic Morrison Formation. Production for 1999 is estimated at 25,000 tons of ore at an average grade of 0.26 percent U_3O_8 and 1.7 percent V_2O_5 equaling 130,000 pounds of U_3O_8 and 850,000 pounds of V_2O_5. The ore is trucked to the company's White Mesa Mill in Blanding, Utah. The mine shut down operations in June because of poor commodity prices.

About 90 percent of vanadium production is used to produce ferrovanadium, which when alloyed with steel imparts additional hardness and strength. Other applications include pigments, catalysts, electronics, and titanium-aluminum-vanadium alloys for the aerospace industry.

The total value of the Colorado uranium production in 1999 in the state is about $5 million. Colorado's vanadium production in 1999 has an estimated value of about $2 million.

METALS

Molybdenum

The Henderson Mine in Clear Creek County operated by Cyprus Amax Minerals Company is the nation's top producer of primary molybdenite (see Fig. 24 and Table 16 for a location map and brief description of all the metal mines in the State). In 1999 the mine and mill produced an estimated 21 million pounds of contained molybdenum, down 30 percent from the 30.1 million pounds produced in 1998 (Fig.25). According to the U.S. Geological Survey Mineral Information Office the 1999 average price for contained molybdenum is $2.64 per pound. The estimated total value of the produced molybdenum from the Henderson Mine in 1999 is $55 million. Continued price slippage has forced all domestic primary and byproduct molybdenum producers to curtail production. Total domestic production slipped from 117 million pounds in 1998 to 97 million pounds in 1999.

Molybdenite mineralization in the Henderson ore body occurs in veins and vein stockwork systems hosted by a mid-Tertiary age multiple porphyry complex. The Henderson ore body is estimated to contain 800 million tons of ore averaging 0.28 percent molybdenite.

The Henderson Mine was shut down during August and September to allow the installation of the new 10-mile conveyor belt from an underground haulage station to a surface transfer station. The conveyor belt replaces the 10-mile underground train haulage system in use since the mine began production in 1976. There are two other conveyor links in the new ore transport system: a one-mile ramp conveyor belt from the new 2500 ton-per-hour crusher at the 7065 level to a haulage station at just below

Table 16. Table of major mineral producers and prospects in Colorado, numbers refer to Figure 24: Map showing major mineral producers and prospects.

Map No.	Mine Name	Commodity	Type	Owner/Operator
1	Kelsey Lake	Diamonds	OP	Diamond Co. N.L.
2	Schwartzwalder	Uranium	UG	Cotter Corp.
3	Sunday Group	Uranium	UG	International Uranium Corp.
4	Cresson	Gold	OP	Pikes Peak Mining Co.
5	Eagle Gypsum	Gypsum	OP	Centex Contstruction Products
6	Henderson	Molybdenum	UG	Phelps Dodge Corp.
7	Climax	Molybdenum	UG, OP	Phelps Dodge Corp.
8	Black Cloud	Zinc, lead, gold, silver	UG	Asarco, Inc.—closed
9	Sweet Home	Rhodochrosite	UG	Sweet Home Rhodo, Inc.
10	American Soda	Soda ash	SOL	American Soda
11	White River	Sodium bicarbonate	SOL	White River Nahcolite Co.
12	Yule Quarry	Marble	UG	Colorado Yule Marble Co.

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

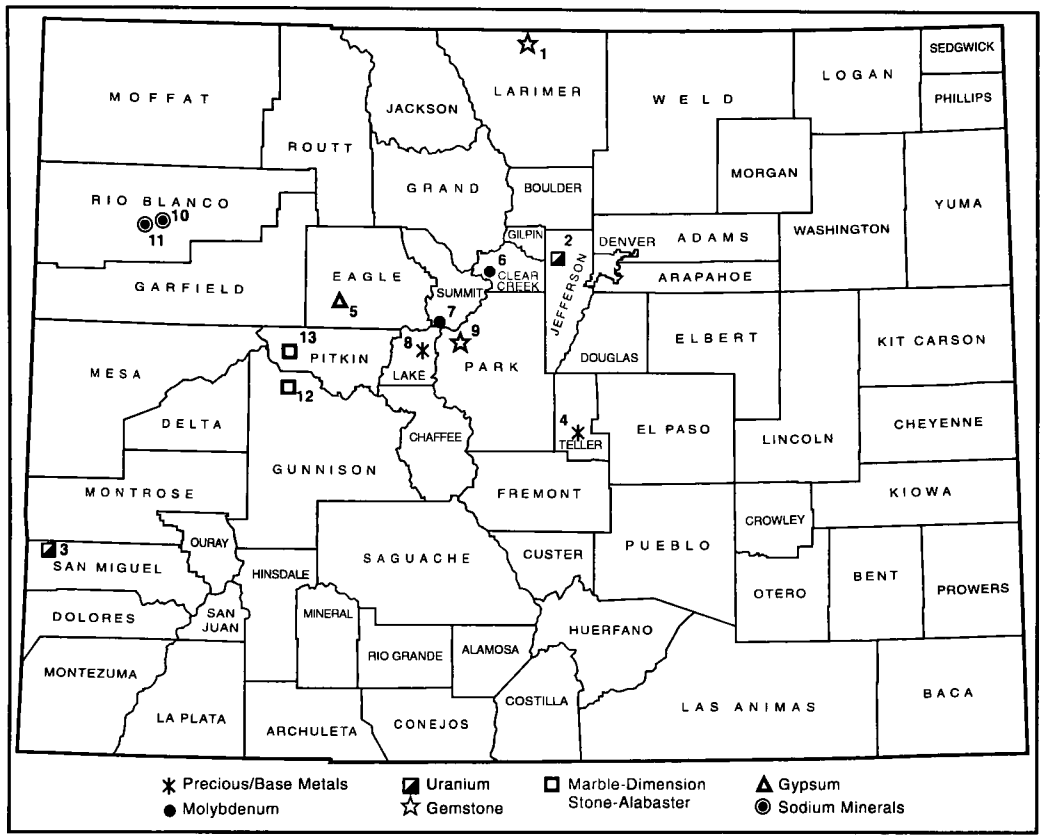


Figure 24. Map showing location of major mineral producers and prospects in Colorado.

the 7500 level, and a 4-mile long overland belt from a surface transfer station to the mill. Also, the mine will change its caving process to enable more efficient ore production and purchase a new fleet of underground 80-ton and 40-ton haulage trucks. These changes will enable the Henderson Mine to lower the overall cutoff grade and increase its ore reserves. As a result the life of the mine will be extended.

On December 2nd 1999 Phelps Dodge Corporation completed its acquisition of Cyprus Amax Minerals Company, which includes all Cyprus' Colorado molybdenum interests: the Henderson Mine, the Climax Mine in Lake County, and the Mount Emmons property in Gunnison County. The continuing depressed price for molybdenum prompted Phelps Dodge Corporation to announce a 20 percent staff cutback, which will result in the loss of 110 jobs effective March 31, 2000.

Gold and Silver

The precious metal industry in Colorado set a modern era (post World War II) production record in 1996 with approximately 250,000 ounces of gold and 312,000 ounces of silver (Fig. 26). Since that record year, two of the three mines that produced gold in the state have shut down. The San Luis Mine in Costilla County shut down in late 1996 because of exhaustion of the ore body, and the Black Cloud Mine in the Leadville district of Lake County shut down in January 1999 for the same reason. In 1999 the sole major precious metal producing mine in the state is the Cripple Creek and Victor Gold Mining Company (CCVGMC) Cresson Mine in the Cripple Creek district of Teller County. The total gold production for Colorado in 1999 was 231,000 ounces, down two percent from the 1998 total of 236,000 ounces, which came from two mines. Silver production for 1999 is estimated at 81,000 ounces.

A mid-Tertiary alkalic volcanic complex hosts gold ore at the Cripple Creek district. The district was discovered in

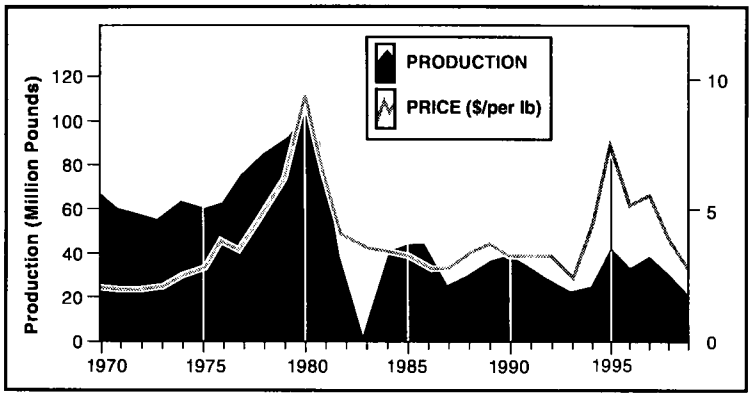


Figure 25. Colorado molybdenum production.

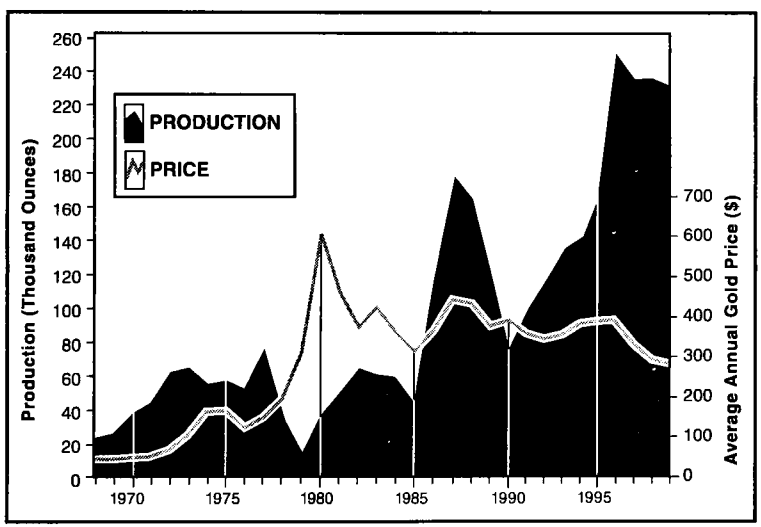


Figure 26. Colorado gold production.

1891 and has produced over 22 million ounces of gold. Early mining in the district was from "bonanza" high grade (one to two ounces of gold per ton) vein deposits. Current mining efforts are on the low grade disseminated gold ore.

Gold prices remained in the doldrums for most of the year. In early October, European central banks announced that they would limit their gold sales for the next five years. The news caused a temporary rise of gold prices above the $300 per ounce mark; however, gold soon sunk back to its current levels below $300.

During 1999 CCVGMC mined a total of 40 million tons of material at the Cresson Mine which includes 10.4 million tons of ore at a grade of 0.03 ounce of gold per ton. The total 1999 production at the Cresson Mine was 231,000 ounces of gold and an estimated 81,000 ounces of silver. The cash operating cost for gold is $167 per ounce. The recovery rate for gold is about 65 percent. CCVGMC plans to increase metal production in 2000 to 246,000 ounces of gold and 86,000 ounces of silver. The mine and mill complex employ 288 people with an annual operating budget of $43 million. Present operating costs are $0.69 per ton material mined and $1.28 per ton ore treated.

CCVGMC continued its ambitious and successful exploration and development drilling program in 1999. Approximately 553,000 feet of reverse circulation and core drilling were completed at a cost of approximately $8 million. The company had good reason to continue its strong exploration and development drilling campaign; given that the 1998 drilling program resulted in the addition of 42.3 million tons of ore containing 1.6 million ounces of gold. Because of low gold prices, the current plan is to reduce the rate of exploration drilling in 2000 and 2001 to about 250,000 feet per year. At the end of 1998 the Cresson Mine had a proven and probable reserve of 127 million tons at a grade of 0.0339 ounce of gold per ton for a total of 4.3 million ounces. Exploration in 1999 increased gold ore reserves to 4.9 million ounces.

In February 1999, CCVGMC received approval from the Colorado Division of Minerals and Geology to increase the size of its leach pad to handle an additional 50 million tons of ore. As part of that addition the Cresson pit will be made wider and deeper and two new

open pits will be developed. A new plan just announced in February 2000 will essentially double the ore handling capacity of the mine to about twenty million tons of ore a year with the installation of a second crusher system. The new plan will also include new 240-ton ore hauling trucks. The mine currently uses 90-ton trucks. The new plan will extend the surface mine life to 2012. CCVMGC will investigate the underground mining potential of the orebody for the years after 2012.

In March 1999, AngloGold, the world's largest gold producer, purchased Minorco's 67 percent share of the CCVGMC. AngloGold is a subsidiary of Anglo American Corporation of South Africa. The deal, worth about $550 million, included Minorco's 70 percent share of the Jerritt Canyon Mine in Nevada and other interests in gold mines in Brazil and Argentina. Golden Cycle Gold Corporation of Colorado Springs retains its 33 percent interest in CCVGMC.

Precious metals were produced as a by-product of base metal mining at the Black Cloud Mine in the Leadville district, which closed permanently in mid-January 1999.

Leadville Mining and Milling Corporation announced in March that it had commenced mining and milling operations at its Hopemore Mine in the Leadville district. In July the company reported that it had encountered high-grade gold mineralization, often assaying two ounces per ton, but up to six ounces per ton. Also, the company announced that it had recovered about 600 ounces of gold in concentrate form.

ITEC Environmental reprocessed tailings from old mines in the area around Gold Hill in Boulder County for a brief period in 1999. The company acquired the Gold Hill Mill site and an additional 700 acres of old mining properties in the area with the hope of a gold price better than $300 per ounce. The company shut down operations in February and the property remains in a standby status.

Base Metals

Asarco's Black Cloud Mine near Leadville (Fig. 24) is an underground room and pillar mine with a daily production capacity of 875 tons. The ore body is a complex massive sulfide deposit hosted by the Leadville Limestone. In 1998 the mine produced approximately 200,000 tons of ore with an average grade of 3.5 percent lead, 8.5 percent zinc, 0.13 percent copper, 1.8 ounces per ton silver, and 0.05 ounce per ton gold.

In January 1999 mining operations at the Black Cloud Mine ceased. The company continued an exploration drilling program until June, but they were unsuccessful in locating any significant ore reserves. Underground salvage and reclamation work began in summer and will continue for several years. Only the water treatment plant will remain in operation.

The mine began production in 1969 and was the largest private employer in Leadville. The Black Cloud Mine was the last operating mine in the 140-year old Leadville district. About 100 miners were laid off at the end of January 1999 leaving only 23 employees to complete salvage and reclamation work (as of October 1999).

In September, the Leadville Corporation announced plans to secure funding to reopen the Diamond and Resurrection Mine in the Leadville district. The Diamond and Resurrection Mine closed in 1989 after being charged several million dollars by the EPA for cleanup responsibilities in the Leadville Superfund site. The company has reached a settlement with EPA and is anxious to begin mining again. The company claims that there are 940,000 tons of identified ore worth about $75 to $100 million at the mine.

CONSTRUCTION MATERIALS AND INDUSTRIAL MINERALS

Introduction

The most economically significant segment of the construction material industry in the state is sand and gravel and crushed stone. Other important con-

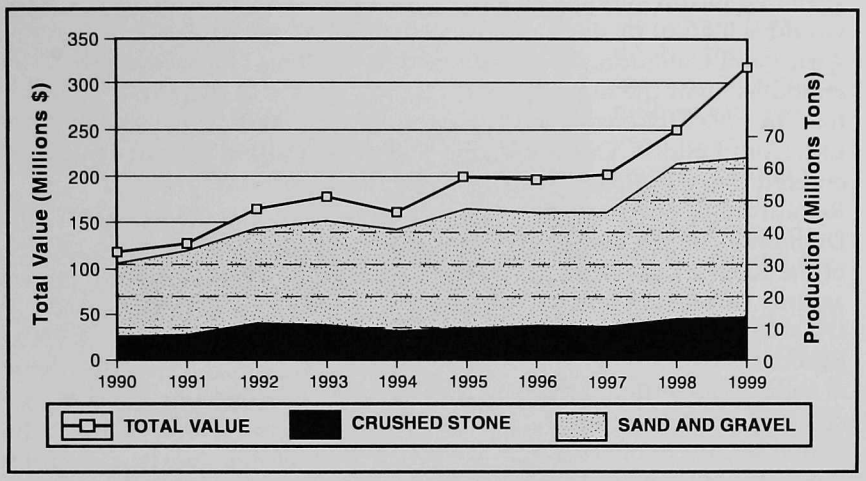


Figure 27. Colorado crushed stone, sand and gravel production.

struction materials and industrial minerals produced in Colorado include gypsum, dimension stone, silica sand, sodium minerals, and gem stones. Other construction materials and industrial minerals produced in the state during 1999 but not discussed in this report include peat, bentonite clay, helium, common clay, and kaolin.

Sand, Gravel, and Crushed Stone

The sand, gravel, and crushed stone industry produced approximately 62.9 million tons of material in 1999, up four percent from 60.4 million tons in 1998. The value of the 1999 production is estimated to be $317 million (Fig. 27) up a strong 22 percent from the 1998 value of $259 million. The disparity between the percent increase of production and value is a trend worth observing. The high demand and difficulty of obtaining permits for new quarries along the Front Range may be a strong factor in the robust value increase of this commodity in 1999 (Fig. 28). Continued residential building in Colorado, especially in the Front Range counties, is largely responsible for the growth in construction material production and value.

Silica Sand

Colorado Silica Sand, Inc. of Colorado Springs produces approximately 200,000 tons a year of specialty 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 company quarries several nearby Quaternary age eolian deposits that are composed of mostly well sorted and well-rounded grains of quartz.

Dimension Stone

After a difficult year filled with legal problems the Yule Marble Quarry near Marble, Colorado is back in production under new ownership. The former owner, Colorado Yule Marble Company, was dissolved in March 1999 leaving behind disgruntled customers and several unpaid bills. The new owner is Sierra Minerals Corporation based in

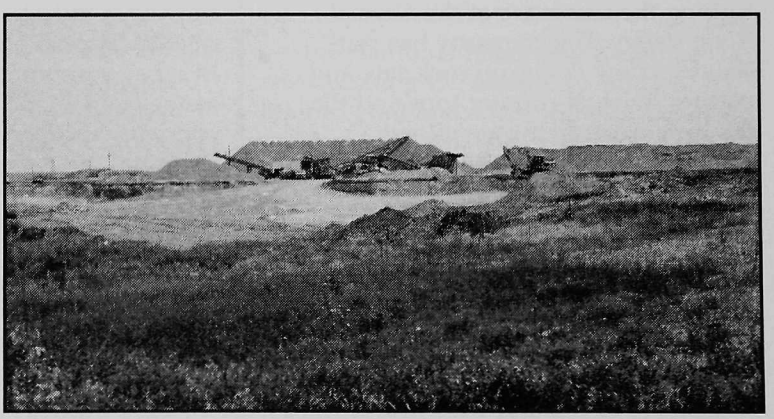


Figure 28. Quarry in Rocky Flats alluvium near Rocky Flats, northern Jefferson County.

Englewood, Colorado. Sierra Minerals acquired a new mining permit from the Colorado Division of Minerals and Geology in August and began producing about 100 tons of marble a month from stockpiled inventory. The company started cutting new stone in January 2000. The primary customer is Columbus Marble Company in Mississippi.

Avalanche Creek Marble and Alabaster, LLC continued to increase its mining efforts at their alabaster and marble mine in Pitkin County. The underground mine develops an alabaster and black marble deposit in the Pennsylvanian Belden Formation. Robert Congdon, the owner and founder of the company obtained State and Federal mining permits in 1992, and after a long struggle with county officials finally began mining in 1998. Continued monitoring by the county has demonstrated that the mine can operate without disturbing the ambience of the Crystal River valley. The company has purchased a new Pelligrini rock saw and is cutting finished counter tops and tile not only from their own mined alabaster and marble, but sandstone from other local quarries.

Gem and Specimen Minerals

Colorado Diamond Co., a subsidiary of Redaurum Ltd., began production in May 1996 at the Kelsey Lake Mine in the State Line district of Larimer County, becoming North America's first large-scale, commercial diamond mine. In 1998 Redaurum announced that it would sell all of its diamond interests in Africa and Colorado. As a result of that announcement the mine ceased production. In 1999 McKenzie Bay International Ltd. from London, Ontario announced it entered into a definite agreement with Redaurum to purchase Colorado Diamond Co., the owner and operator of the Kelsey Lake Mine. A lawsuit against Redaurum and Colorado Diamond Co. by Union Pacific Land Resources over ownership of the mineral rights was settled; however, the lawsuit had a detrimental effect on the company's ability to operate profitably. In January 2000, Colorado Diamond Co. declared bankruptcy in order to complete its sale to McKenzie Bay. At last report McKenzie Bay was planning to get the mine back into production by spring 2000.

Over 60 percent of the diamonds recovered at Kelsey Lake are of gem quality. Typical gem quality percentages in other economic kimberlite deposits range from 20 to 30 percent. In 1996 the company recovered a 28.3 light yellow diamond, the largest ever discovered in the State Line district and the fifth largest found in North America. The light yellow diamond was cut into a pear-shaped gemstone weighing 5.3 carats. Prior to the discovery of the light yellow diamond, a 14.2-carat, white, clear diamond was the largest discovered in the State Line district and at the Kelsey Lake Mine. The Kelsey Lake prospect consists of eight kimberlite pipes; however, the mining program was focussed on the two largest pipes. These two pipes have a surface area of about 20 acres and contain about 19 million tons of ore down to a depth of 330 feet.

The Sweet Home Mine, an old silver prospect, in Park County was reopened as a rhodochrosite mine in 1991. Over the past eight years the mine has produced several world class specimens of cherry red rhodochrosite crystals including one thought to be the largest in the world. Some of the larger crystals set in a quartz and sulfide mineral matrix have commanded prices in the hundreds of thousand of dollars.

Gypsum

The Centex American Gypsum Corporation produced 450,000 tons of gypsum in 1999 from its open pit gypsum mine and plant in Gypsum, Eagle County. That figure is an increase of 10 percent over the 1998 production of 410,000 tons. The gypsum ore is mined from an open pit mine 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 a two-year expansion program to

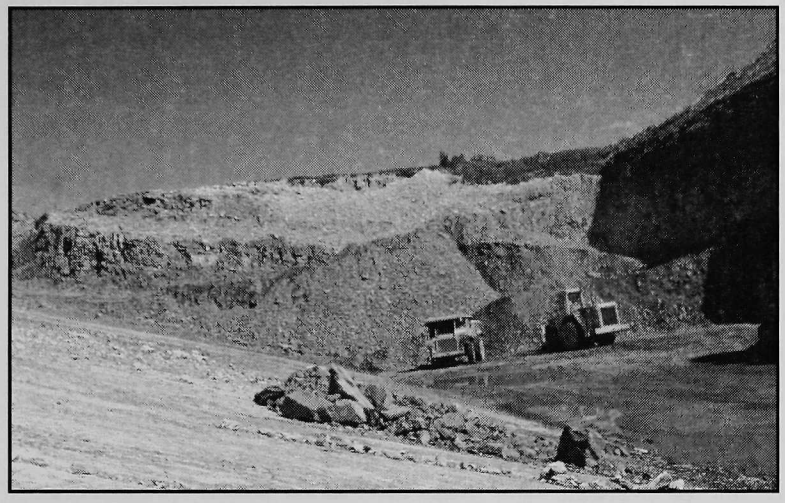


Figure 29. Holnam limestone quarry near La Porte, Larimer County. Loading Niobrara Limestone for use in cement production.

increase the production capacity of the mine and plant to 550,000 tons per year. Production is estimated to increase to 550,000 tons for 2000 and 2001. Employment has increased over the past year from 100 to 120 employees.

Cement

Holnam, Inc. has begun construction on a $200 million addition to its existing portland cement plant in Florence in order to meet increased demand because of Colorado's strong economy. The existing plant will be converted from a multi-kiln wet process to single-kiln dry process. Start-up for the new plant is expected in the first quarter of 2001. The expansion will more than double the plant's capacity to about 2 million tons per year. Industry experts estimate that Colorado cement demand will be about 2.5 million tons in 1999. Colorado will probably still be a net importer of cement for the next few years (Fig. 29).

Grupo Mexico has applied for various permits for their proposed cement plant in the designated free trade zone south of Pueblo.

Sodium Minerals

The White River Nahcolite Company produced approximately 90 percent of the plant's nameplate capacity of 110,000 tons a year of nahcolite, sodium bicarbonate, at their solution mine in the Piceance Basin, Rio Blanco County. The company produces both food and industrial grade sodium bicarbonate (baking soda) from the 20 to 25 feet thick "Boies Bed", a Tertiary age lacustrine deposit at a depth of 2,000 feet. Current production is from several solution cavities. The plant has a staff of twenty-two persons.

METAL EXPLORATION AND DEVELOPMENT ACTIVITIES

Sunshine Mining and Refining Co. is conducting pre-feasibility studies of the high grade silver deposit at the Revenue-Virginius Mine in Ouray County. The Revenue-Virginius Mine is estimated to contain 6.2 million ounces of silver within 260,000 tons of ore at a grade of 24 ounces per ton silver, 0.6 ounces per ton gold and a combined 5.9 percent copper, lead, and zinc. Historically, the Virginius vein contains some of the highest grade silver ore in the state, averaging about 125 ounces per ton. Mineralogy and grades of the tetrahedrite-galena-quartz vein persist over 3,500 feet of depth, based upon exposures in the old mine workings and in drill core. No new work was conducted in 1999.

International Panorama Resources is re-evaluating the feasibility study of its Platoro gold and silver mine in Conejos County. The 1998 feasibility study outlined 605,000 metric tons of proven and probable resources grading 0.174 ounce per ton gold and 5.96 ounce per ton silver.

American Soda Company of Glenwood Springs spent most of 1999 acquiring permits from Garfield and Rio Blanco Counties and the Bureau of Land Management for its Piceance Creek Basin soda ash solution mine, pipeline, and processing and loading facilities. All

of the permits have been granted and construction is underway. The company plans to use a steam tunnel to convert the sodium bicarbonate from the nahcolite to sodium carbonate, or as it is commonly known, soda ash. American Soda plans to produce about 1.4 million tons of soda ash and sodium bicarbonate per year. The planned solution mine will be located near Meeker, Colorado. A 42-mile pipeline will transport the pregnant solution to a redesigned Unocal oil shale processing plant north of Parachute for further refinement and packaging.

AmerAlia is in the process of applying for permits for another sodium bicarbonate solution mine in the Piceance Creek Basin. The first stage of the mine will be a pilot project producing about 100,000 pounds of sodium bicarbonate a year. In January, the company announced that it had received approval from the Bureau of Land Management to proceed with mine development.

In 1998 Calais Resources of British Columbia completed the purchase of the assets of Hendricks Mining Co., the Cross-Caribou mining project in the Grand Island district, Boulder County. The company conducted an exploration-drilling program during 1998. Results of the exploration program show that there 1,425,618 tons of indicated resources grading 0.298 ounce per ton gold and 8.23 ounces per ton of silver on the property. The contained precious metals in the resource are 424,540 ounces of gold and 11,726, 460 ounces of silver.

Teck Corporation acquired the White Earth titanium oxide project near Powderhorn, Gunnison County in 1990. Since that time the company has outlined a reserve of 46 million tons of ore grading 13.2 percent TiO2 in the Deldorado Ridge area of the property according to a recent article by K.C. Shaver and R.A. Lunceford in the Canadian Institute of Mining Bulletin. An open-ended geological resource is estimated at 1.75 billion tons at a grade of 10.9 percent TiO2. First stage pilot test confirmed that the titanium concentrates could be produced by flotation methods. Second stage testing is currently refining the process. Pigment produced during second stage testing will be used for advance marketing studies and product development.