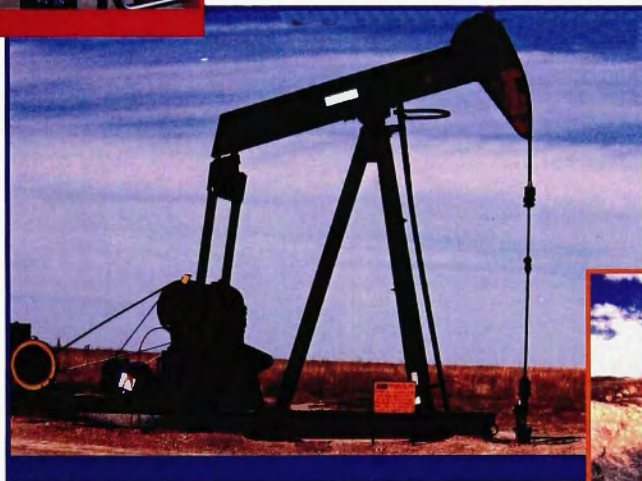
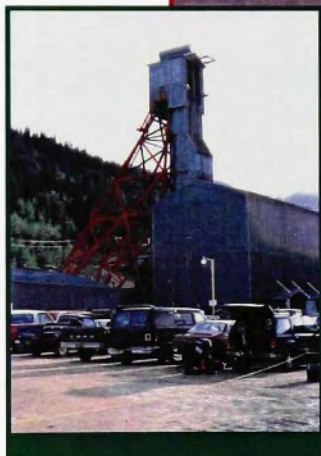
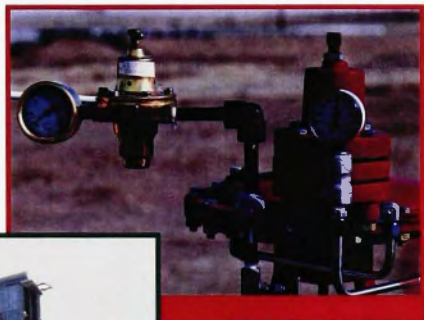


**Information Series 52**

# **Colorado Mineral and Mineral Fuel Activity, 1998**

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



**Colorado Geological Survey  
Department of Natural Resources  
Denver, Colorado  
1999**

Funding for this publication came from Colorado severance taxes, which are derived from the production of oil, gas, coal, and minerals

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Cover: 1) Headframe at Black Cloud Mine near Leadville, Lake County; 2) Wellhead gauges and regulator, helium well, Cheyenne County, photo by Jennie Hemborg; 3) Champlin-Aldrich A #5 well, Cheyenne Wells field, Cheyenne County, photo by Jennie Hemborg; 4) Colowyo Coal Mine, Moffat County



# INTRODUCTION AND ECONOMIC FACTORS

The Colorado Geological Survey Mineral and Mineral Fuels Section estimates the total value of 1998 mineral and mineral fuel production in Colorado to be \$2,769 million dollars (Fig. 1).

Mineral fuel production value for 1998 is estimated at oil—\$280 million, natural gas—\$1,349 million, carbon dioxide—\$77 million, and uranium and vanadium—\$15 million. The total value of oil, natural gas, and carbon dioxide production in 1998 was \$1,714 million, a 15 percent decrease from the 1997 value of \$2,026 million. Lower oil and natural gas prices and decreased oil production are the primary reasons for the decline in value. Natural gas production in the state reached a new record of 692 billion cubic feet in 1998.

Coal production increased from the 1997 level of 27.4 million tons to a new record of 29.6 million tons in 1998. Coal prices, which vary from mine to mine, are estimated at an average \$15 per ton for 1998.

The U.S. Geological Survey Mineral Information Office estimates the value of the 1998 non-fuel mineral production to be \$604 million. This figure is an increase of 15 percent from the 1997 value of \$524 million. The increased

value is due mostly to heightened construction materials, sand and gravel, and crushed stone production.

The value of Colorado's mineral and mineral fuel production is realized in many ways including employment, taxes, and royalties that flow back to the state and local governments. The value of Colorado's share of federal mineral royalties decreased 6 percent to \$41,172,269 from \$43,982,442 in 1997. 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 state 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

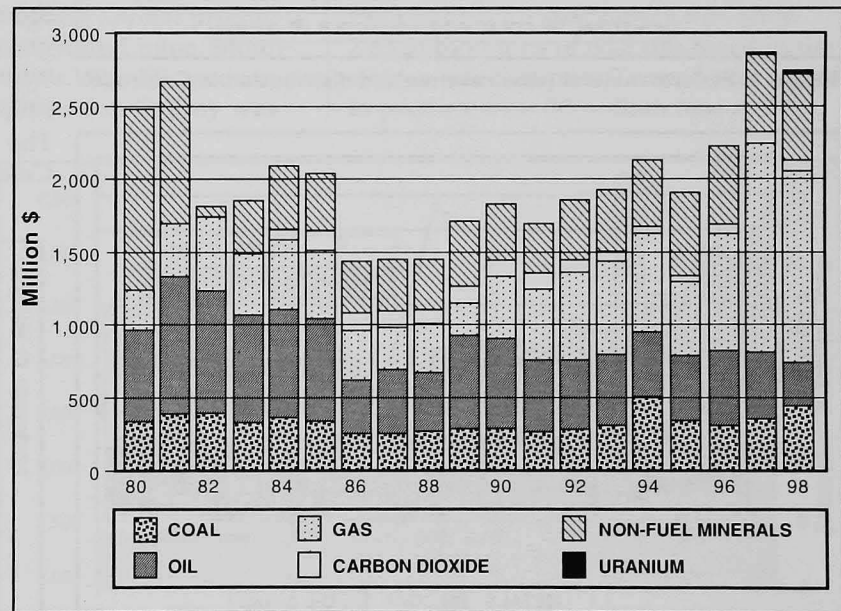


Figure 1. Value of Colorado mineral and mineral fuel production.

agencies within the Department of Natural Resources that promote and regulate the mineral and mineral fuel industries. Severance tax collections in

fiscal year 1998 totaled \$29.74 million (Fig. 3).

Estimated property taxes paid in 1998 to the counties from mineral and

of Business Administration estimates employment in the mineral and mineral fuel industries in 1998 to be 13,900 workers, about level with the employment in 1997. This sector of the economy continues a steady ten-year decline in employment from a 1989 level of 19,600 persons. The outlook for 1999 is not encouraging as low oil and gas prices continue to cause mergers and lay-offs in the industry.

According to the Colorado Department of Labor and Employment, the average annual wage in 1998 for the oil, gas, and mining industries is an estimated \$59,900. The estimated per capita income for Colorado in 1998 is \$28,180. As in previous years, the mineral and mineral fuel industry is one of the highest paid sectors of the Colorado economy. The total contribution of mineral and mineral fuel employees' wages to the state's economy is about \$832 million.

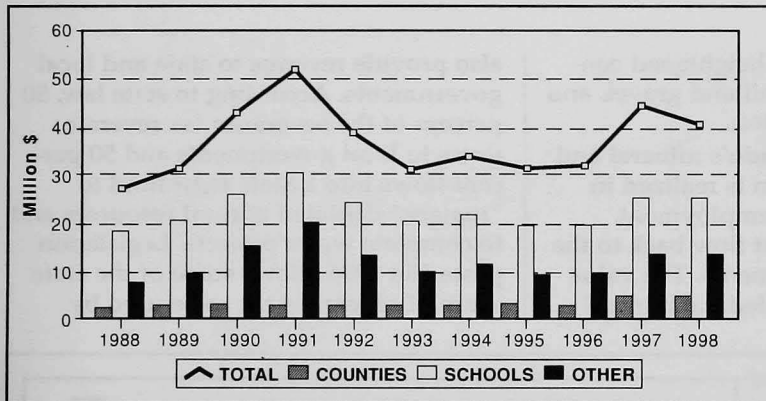


Figure 2. Federal mineral lease revenue and distribution in Colorado.

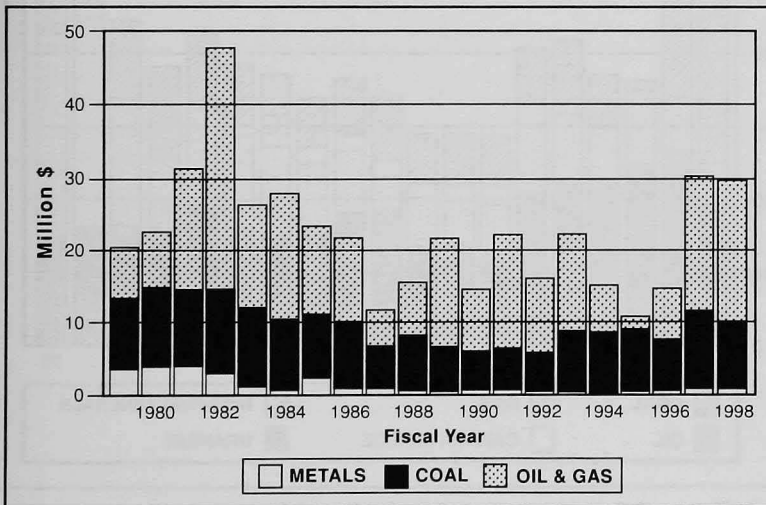


Figure 3. Colorado severance tax collections.

mineral fuel properties totaled \$140 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

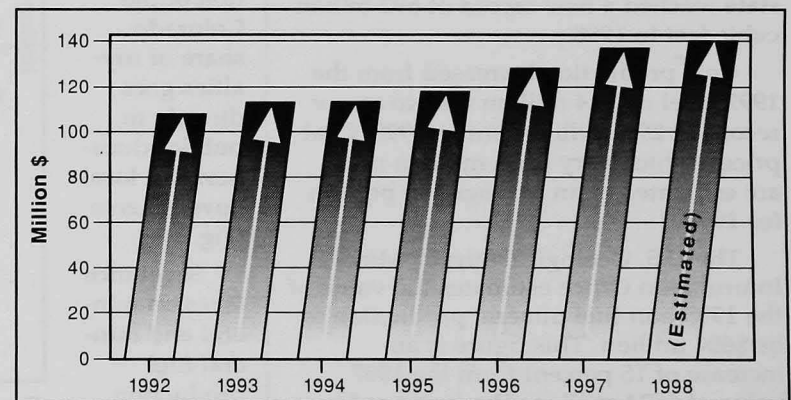


Figure 4. Property tax revenues from mineral properties.

## COAL

### Production

The Colorado coal industry in 1998 continued the trend of production growth that began in the mid-1980s (Fig. 5). Colorado coal companies mined a record 29.6 million tons of coal, a 9.2 percent increase from 1997. The U.S. Department of Energy (DOE) Energy Information Administration (EIA) ranked Colorado 12<sup>th</sup> among coal producing states in 1997. EIA data for the first three-quarters of 1998 indicate that Colorado production had increased significantly over the same period in 1997, projecting Colorado into 11<sup>th</sup> place among coal producing states nationally.

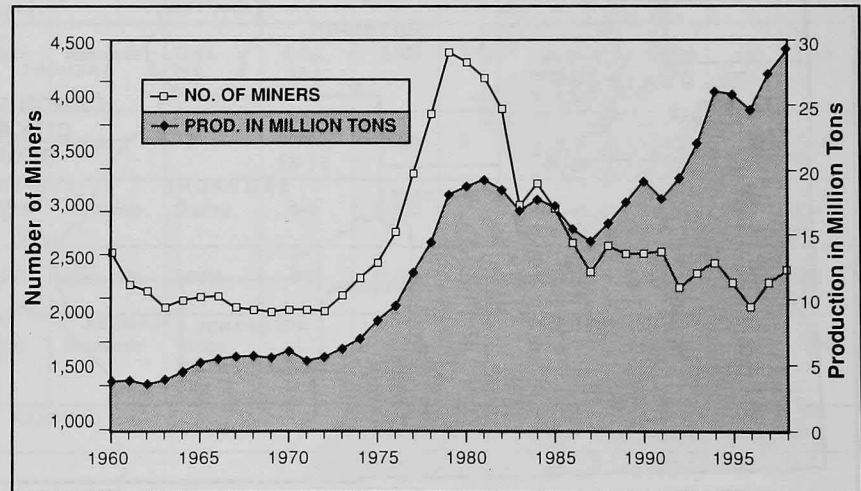
During 1998, there were 12 mines producing coal in the state (Fig. 6), down from 14 in 1997. The Bowie #1 Mine in Gunnison County has been idle since December 1997 and the McClane Canyon Mine in Garfield County was idled in April 1997.

Coal was produced from nine of Colorado's 63 counties in 1998—Delta, Fremont, Gunnison, La Plata, Mesa, Moffat, Montrose, Rio Blanco, and Routt (Fig. 7). Coal production from the eight underground mines was two-thirds of

the total state coal production, and surface mine production only one-third. The three largest mines each produced over 5.8 million tons (Table 1). Together, these three mines accounted for over 68 percent of the total state production. The state's largest producer was the Cyprus Amax Twentymile (Foidel Creek) underground mine in Routt County with 8.45 million tons setting the state production record with the highest annual production from an underground mine. Mountain Coal Company's West Elk underground mine in Gunnison County was

the next highest producer with 5.94 million tons. Moffat County's Colowyo Mine (Fig. 8) was the third most productive mine in the state, and the most productive surface mine, with 5.82 million tons. Routt County was the leader for coal production in 1998 with over 10 million tons of coal produced from the Twentymile underground mine and the Seneca surface mine combined. January 1999 figures for coal production show 2.65 million tons of coal produced in the state, a rate that puts Colorado on a pace to produce over 30 million tons in 1999.

**Figure 5. Coal production and employment in Colorado, 1960–1998.**  
[Source: Colorado Division of Minerals and Geology.]





**Table I. Colorado mines that produced coal in 1998. (Source: DMG)**

Mine No.	Mine Name	County	Coal Region	Coal Field	Operator	Twp., Rge.	Geologic Formation	Bed Names	Seam Thickness (ft)	BTU Avg.	Mine Type	Mining Method	1998 Prod. (tons)	Dec 1998 Miners	Ship-ment Method
1	Bowie #2	Delta	Uinta	Somerset	Bowie Resources Ltd.	13S, 91W	Mesaverde	D,B	8-16	12,000	U	Continuous	1,208,347	133	Truck, rail
2	Southfield	Fremont	Canon City	Canon City	Energy Fuels Coal, Inc.	20S, 69W	Vermejo	Jack-O-Lantern Red Arrow	6 5.5	11,100	U	Continuous	226,334	33	Rail, truck
3	West Elk	Gunnison	Uinta	Somerset	Arch (ACI) Mountain Coal Co.	13S, 90W	Mesaverde	B	16	11,700	U	Longwall, continuous	5,939,147	242	Rail
4	Sanborn Creek	Gunnison	Uinta	Somerset	Oxbow Carbon & Minerals, Inc. (Pacific Basin Resources)	13S, 90W	Mesaverde	B	18	12,375	U	Continuous, longwall	1,529,653	158	Rail
5	King Coal	La Plata	San Juan River	Durango	National King Coal, LLC	35N, 11W	Menefee (Mesaverde Group)	Upper bed	5.3-6	13,100	U	Continuous	283,212	62	Truck
6	Roadside (S. Portal)	Mesa	Uinta	Grand Mesa	Powderhorn Coal Co. (Peabody)	11S, 98W	Mesaverde	Cameo B	7-8	11,800	U	Continuous	340,458	37	Conveyor
7	Colowyo	Moffat	Uinta	Danforth Hills	Colowyo Coal Co. (Kennecott)	4N, 93W	Mesaverde	A-F, X,Y	8 beds- 5.3-12.3	10,461	S	Dragline, shovels, dozers	5,823,379	281	Rail
8	Trapper	Moffat	Green River	Yampa	Trapper Mining, Inc.	6N, 90W	Mesaverde	G,H,I, Q,R	4, 6.5, 13, 4	9,900	S	Dragline, dozers, hyd. excav.	2,187,356	120	Truck
9	New Horizon	Montrose	San Juan River	Nucla-Naturita	Western Fuels Assn.	46N, 15W	Dakota	1,2	1.6-3.3, 5.9-7.9	10,300	S	Shovels, dozers	321,755	24	Truck
10	Deserado	Rio Blanco	Uinta	Lower White River	Blue Mountain Energy, Inc.	3N, 101W	Mesaverde	D seam	8-9	10,930	U	Longwall, continuous	1,715,701	130	Rail
11	Twentymile (Foidel Creek)	Routt	Green River	Yampa	Twentymile Coal Co. (Cyprus Amax)	5N, 86W	Mesaverde	Wadge	9.5	11,200	U	Longwall, continuous	8,450,394	359	Rail
12	Seneca II, Seneca II-W, Yoast	Routt	Green River	Yampa	Peabody Western Coal Co	5N, 87W	Mesaverde	Wadge, Wolf Cr., Sage Cr.	11.7, 20.4, 4.6	11,908-12,581	S	Dragline, loaders	1,589,497	86	Truck, rail
<b>Total</b>													<b>29,615,233</b>	<b>1,665</b>	

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



Colorado coal production reached a significant milestone in 1998 by surpassing cumulative production of one billion tons. Total cumulative coal produced in Colorado from 1864 through

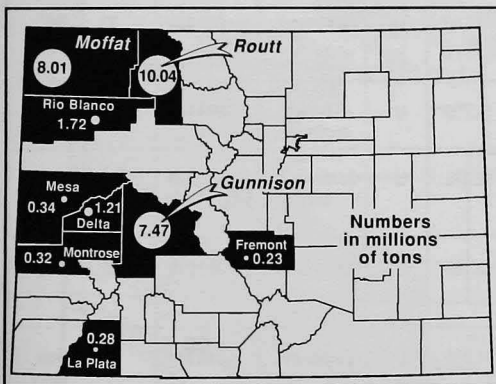


Figure 7. Colorado coal producing counties, 1998. Size of circle indicates relative amount of coal production in each county. Source: Colorado Division of Minerals and Geology.

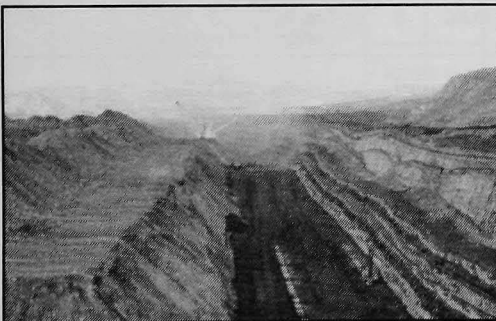


Figure 8. Colowyo surface mine, Danforth Hills Coal field, Moffat County.

1998 is estimated at 1,023.4 million tons. This figure is based on available records of production since 1907 and estimates of coal tonnages produced before that time. Cumulatively, most of the coal has been produced in the Green River Region with 278.4 million tons of coal from Moffat and Routt Counties, or 27.2 percent of the statewide total (Table 2). Current production trends in the Uinta Region (16.6 million tons produced in 1998) should make that region the cumulative coal production leader by 2000.

### Economic Impact

According to the Colorado Division of Minerals and Geology, Colorado's coal mines employed 1,665 miners in December 1998 (Table 3), an increase of 12 percent over the 1,591 miners at the

end of 1997. The increase in employment continues the upturn in coal employment that began in 1997. According to the Colorado Department of Labor and Employment and the National Mining Association, the number of employees in the Colorado coal mining industry was 2,228. The average annual wage (both union and non-union) of all Colorado coal mine employees was \$59,030 in 1997. Colorado ranks 5<sup>th</sup> in the nation in mining wages.

According to mineral revenue auditors with the Colorado State Land Board and the Colorado Department of Revenue, about \$28.44 million came to the state from taxes, royalties, and rentals from coal producers during the 1997–1998 fiscal year (Fig. 9).

Table 2. Cumulative coal production in Colorado by coal region, 1864–1998.

Coal Region	County	Production (millions of tons)	Percent of State Total
Canon City	Fremont	47.57	4.65
Denver	Adams, Arapahoe, Boulder, Douglas, Elbert, El Paso, Jefferson, Larimer, Weld	134.20	13.11
Green River	Moffat, Routt	278.44	27.21
North Park	Jackson	7.07	0.69
Raton Mesa	Las Animas, Huerfano	262.09	25.61
San Juan River	Archuleta, Dolores, La Plata, Montezuma, Montrose, Ouray, San Miguel	16.27	1.59
South Park	Park	0.72	0.07
Uinta	Delta, Garfield, Gunnison, Mesa, Moffat, Pitkin, Rio Blanco	277.06	27.07
<b>Total</b>		<b>1,023.42</b>	<b>100.00</b>

**Table 3. Colorado coal production and miners by county, 1998.**

County	Production	No. of miners	No. of Mines Surface/Underground
Delta	1,208,347	133	0/1
Fremont	226,334	33	0/1
Gunnison	7,468,800	400	0/2
La Plata	283,212	62	0/1
Mesa	340,458	37	0/1
Moffat	8,010,735	401	2/0
Montrose	321,755	24	1/0
Rio Blanco	1,715,701	130	0/1
Routt	10,039,891	445	1/1
<b>Total</b>	<b>29,615,233</b>	<b>1,665</b>	<b>4/8</b>

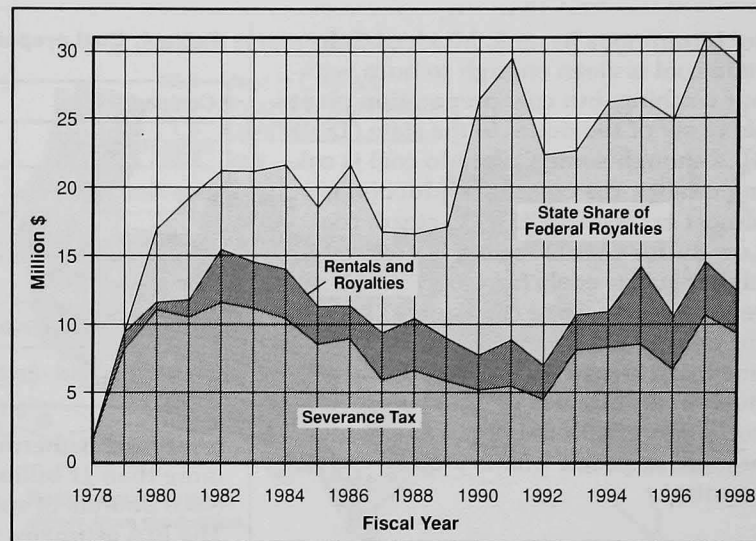
At an approximate price of \$15 per ton, 1998 Colorado coal production is valued at \$444 million. The \$15 price per ton is higher than the lowest spot market price at some of Colorado's coal mines, which ranges from \$12 to \$16 per ton.

### Coal Quality

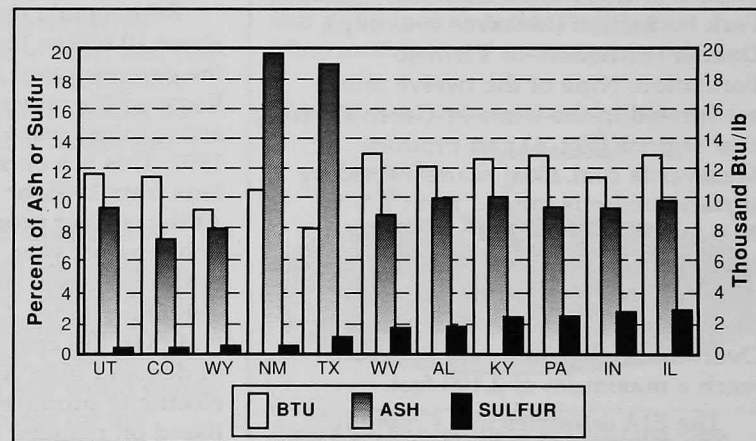
Coal-bearing units underlie some 29,600 square miles or 28 percent of Colorado (Keystone, 1999). The state has some of the highest quality coal, in terms of sulfur and ash content, in the world (Fig. 10). Colorado coal also has some of the lowest mercury concentrations in the nation, which range from 0.08 micrograms per gram mercury in the San Juan River and Uinta regions to 0.09 micrograms per gram mercury in the Raton Region. The national mean concentration

of mercury in coal is 0.2 micrograms per gram (Toole, O'Neil and others, 1998).

Coal resources range in rank from lignite in the Denver Basin to anthracite near Crested Butte, Gunnison County. More than 70 percent of the Colorado coal resource is bituminous and the heat value is high—ranging from 9,900 to 13,100 Btu/lb. Most of the mined coal is bituminous; the remainder is



**Figure 9. Coal income graph. Sources: Colorado Department of Revenue, Colorado State Board of Land Commissioners, and U.S. Minerals Management Service**



**Figure 10. Quality comparison of coal produced in Colorado and selected states. Source: Keystone Coal Industry Manual, 1998.**

subbituminous in rank. Much of Colorado coal is clean enough to burn without washing, but coal preparation plants serve six of the mines in the state (Table 4). Although some Colorado coal is coking quality, the current production is almost exclusively used as steam coal. Low-sulfur Colorado coal is mixed with higher-sulfur coals from other states to reduce power plant emissions. Demand for cleaner Colorado coal in the 1990s is one main reason for increased coal production. Future use of Colorado coal for compliance with the Clean Air Act is assured at power plants around the country.

### Coal Geology and Reserves

All of the current Colorado coal production is from Cretaceous age coals. In 1998, coal was mined from the Williams Fork Formation (Mesaverde Group), Dakota Formation, or Vermejo Formation. Nine of the twelve mines are located in the Uinta or Green River coal regions (Fig. 6) and produce Mesaverde coal. Coal seams mined by surface methods ranged from 1.6- to 20.4-feet thick. Underground-mined coal seams range from 5- to over 20-feet thick (although the actual maximum thickness recovered was 12 feet). Overburden depths to mined seams reach a maximum of 2,100 feet.

The EIA estimates that Colorado's demonstrated coal reserves (Fig. 11) are about 16.8 billion tons placing Colorado 8<sup>th</sup> in the U.S. in total demonstrated

**Table 4. Coal preparation plants in Colorado. Source: 1999 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
Cyprus Amax Coal Co.	Twentymile (Oak Creek)	250	1995
Energy Fuels Coal	South Field (Florence)	240	1979
Oxbow Carbon & Minerals	Terror Creek (Paonia)	—	—
Powderhorn Coal (Peabody)	Roadside (Palisade)	400	1978

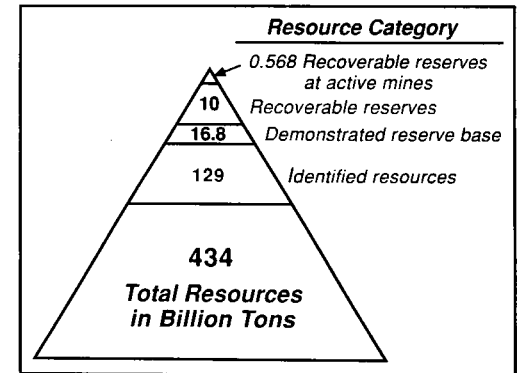
reserves. Furthermore, of that total, more than 11 billion tons are low sulfur (<0.6 pounds of sulfur per million Btu). The EIA estimates that 12.0 billion tons of the demonstrated reserve base are minable underground and 4.8 billion tons are surface minable.

Recoverable reserves in Colorado are about 10 billion tons, or 60 percent of the demonstrated reserve base. Recoverable reserves under lease at active mines were 568 million tons in 1997. This is a decrease of 74.1 million tons from 1996, or an 11.6 percent drop. At the current production rate of 30 million tons per year, this gives a 20-year recoverable coal supply under lease at operating mines. Colorado's low sulfur and high Btu coal should continue to be in demand from American and foreign electricity producers in the future. Based on planned or recent expansions and previous increases in production, the Colorado Mining Association pre-

dicts an increase in annual coal production to over 30 million tons by next year.

### Consumption

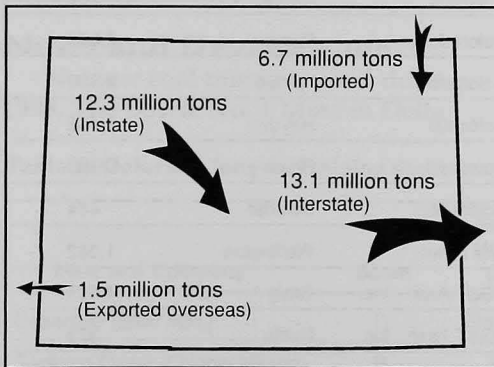
In 1997, 45.4 percent of Colorado's coal production was burned at Colorado power plants and 49 percent was



**Figure 11. Colorado coal resources and reserves. Sources: U.S. Geological Survey and Department of Energy-Energy Information Administration.**

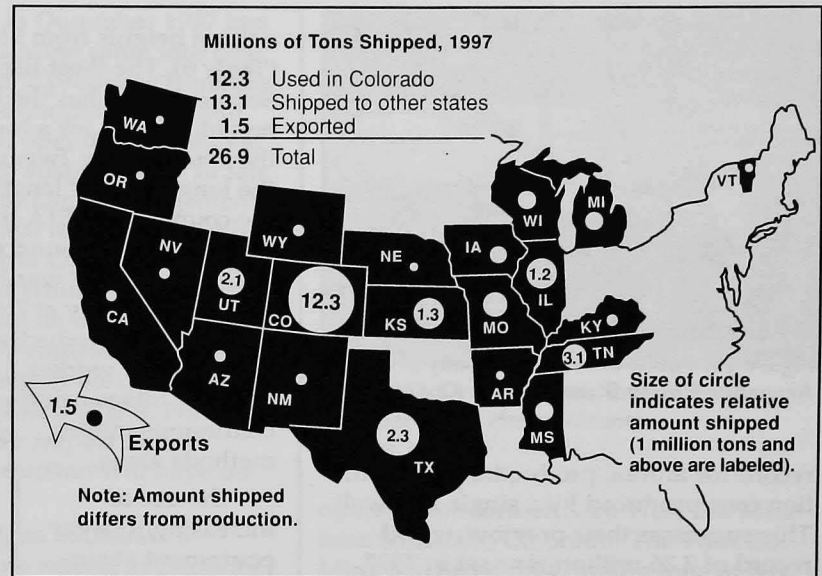
shipped to 22 other states (Figs. 12 and 13). Tennessee, Texas, Utah, Kansas, and Illinois were the largest consumers of Colorado coal. In addition, a total of 1.5 million tons (the remaining 5.6 percent) was shipped to three foreign countries in 1997—Mexico, Japan, and Taiwan. This represented a 97,000-ton increase over the previous year and was due primarily to increased rail traffic to Mexico. This factor offset a decrease in overseas shipments to the Far East.

According to the EIA, total coal consumption within the state in 1997 was 17.9 million tons, an increase of 0.7 million tons over 1996. Ninety-five percent of the energy input at Colorado's electric utilities comes from coal (Fig. 14). Thirteen Colorado steam power plants (Fig. 15) consumed about 17.1 million tons of coal (Table 5). This coal originated in Colorado's Western Slope and



**Figure 12. Colorado coal distribution diagram.** Source: Department of Energy-Energy Information Administration.

**Figure 13. Distribution of Colorado coal in 1997.** Source: Department of Energy, Energy Information Administration

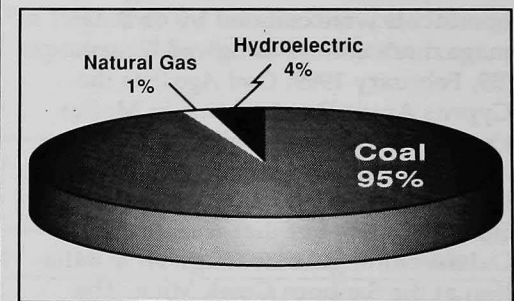


Wyoming's Powder River Basin. Other coal consumers in Colorado were comparatively minor. Industrial plants burned 0.7 million tons in 1997, and residential and commercial consumption was 0.1 million tons. These smaller sectors increased two-fold in utilization from 1996 to 1997.

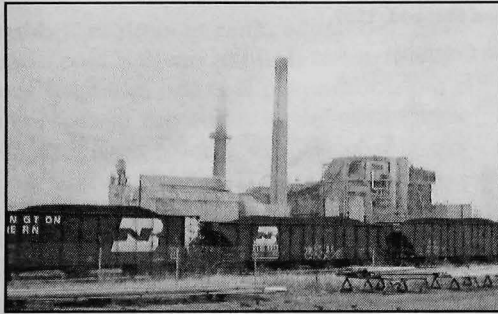
### Productivity and Capacity

The larger underground coal mines in the state have increased coal production by the use of more efficient technology such as longwall mining. Colorado longwall mines broke state and world underground production records for the fourth consecutive year. In 1998, the Twentymile Mine, operated by Cyprus

Amax, set a world record for annual production. With a 114-inch seam height and a 700-foot face, the Twentymile Mine established the current world



**Figure 14. Energy input at Colorado electric utilities.** Source: Department of Energy, Energy Information Administration



**Figure 15. Public Service Company's Arapahoe Power Plant, Denver County.**

record for annual production at 8.4 million tons produced by a single longwall. This surpasses their previous world record of 7.26 million tons set in 1997. The sophisticated longwall technology, installed in 1996, has continued to operate well beyond its value. This mine has panels over three miles long—the longest in the world.

A total of five Colorado longwall operations were counted by *Coal Age* magazine's annual Longwall Census '99, February 1999. *Coal Age* lists the Cyprus Amax Empire Mine in Moffat County in their longwall list; however, it has been idle for several years. Basin Resource's Golden Eagle longwall closed in 1995, but that was offset by Oxbow Mining's new longwall installation at the Sanborn Creek Mine. The longwall systems (Fig. 16) 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 96 to 144 inches (Table 6). The West Elk Mine in Somerset field has the tallest cutting height, 12 feet, for a longwall shearer in the country. The Twentymile Mine has the longest panel length, 17,600 feet, in the country. The EIA stated that productivity of underground mines in Colorado in 1997 was the second highest in the country at 7.44 tons per worker-hour. This productivity compares to 4.32 tons per worker hour for mines using continuous mining methods alone.

The use of increasingly larger equipment at surface mines is a major factor in increased productivity. For example, the Colowyo Mine in Moffat County uses equipment that is among the largest of its kind including a dragline with a 60 cubic yard capacity bucket, 240-ton trucks, loaders with 35 cubic yard capacity buckets, and D11 bulldozers. The Trapper Mine (Fig. 17), also in Moffat County,

uses a large hydraulic excavator as well as a large dragline.

According to the EIA, the overall productivity of Colorado mines (surface and underground combined) was 7.68 tons per worker-hour in 1997. Colorado coal mines (surface and underground combined) are the seventh most productive in the nation. *Coal Age* magazine predicts that the year 2000 will show stable numbers of longwall systems and

**Table 5. Coal-fired power plants in Colorado. (Source: 1999 Keystone Coal Industry Manual)**

No.	Plant	Utility	Location	1997 Consumption (thou. tons)
1	Drake	Colorado Springs	Colorado Springs	757
2	Nixon	Colorado Springs	Colorado Springs	688
3	Arapahoe	PSC† of Colorado	Denver	753
4	Cameo	PSC of Colorado	Cameo	266
5	Cherokee	PSC of Colorado	Denver	2,086
6	Comanche	PSC of Colorado	Pueblo	2,686
7	Hayden	PSC of Colorado	Hayden	1,402
8	Pawnee	PSC of Colorado	Brush	1,953
9	Valmont	PSC of Colorado	Boulder	484
10	Rawhide	Platte River Power	Wellington	1,082
11	Craig*	Tri-State G&T Assn., Inc.	Craig	4,439
12	Nucla*	Tri-State G&T Assn., Inc.	Nucla	378
13	Clark*	Utilicorp United, Inc.	Canon City	137
<b>Total</b>				<b>17,111</b>

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

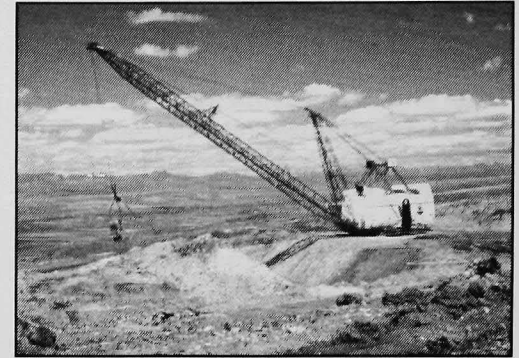


**Figure 16. Longwall shearer at the West Elk Mine, Gunnison County. Photo courtesy of Carol Tremain-Ambrose.**

County went idle in December 1997 just as the Bowie No. 2 Mine came into production. Bowie No. 2 produces from the B and D seams. Development work to support a longwall operation for Bowie Resources has been suspended as of late 1998. The Bureau of Land Management (BLM) withdrew coal leases from both Bowie Resources and Oxbow Mining in the fall of 1998 and would not review any new leases until an environmental impact statement is completed at the end of 1999. This report will be conducted jointly by the BLM and U.S. Forest Service to assess the impact that increased coal production will have on the area.

Mining operations at Oxbow's Sanborn Creek Mine ceased in December 1998 due to a suspected fire in part of the mine. The mine resumed production in January 1999; however, part of the mine is still sealed because of the suspected fire.

On June 1, 1998 Arch Coal, Inc. (ACI) purchased Arco's U.S. coal properties for \$1.14 billion. Accordingly, ACI now



**Figure 17. Dragline operating at the Trapper Mine, Moffat County.**

operates the former Arco West Elk Mine near Somerset, Colorado. The West Elk Mine produced 5.94 million tons of coal in 1998, about 10 percent more than in 1997. ACI would like to increase production to 7.5 million tons over the next few years, but railroad support to the mine may slow this proposed production increase. Rail traffic to the mine improved in 1998 after the service disruptions experienced by the Union Pacific

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

No new coal mines opened during 1998. The Bowie No. 1 Mine in Delta

**Table 6. Colorado longwall mining statistics. Source: *Coal Age*, February 1999.**

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)
Deserado (Blue Mtn.)	D	96-102	96-102	800	6,000	1,600-2,100	30	Joy 4LS DDR 1,030	8,000
Sanborn Creek (Oxbow Mining)	B	180	132	580	4,000	1,500-2,500	30	Joy 4LS DDR 1,030	8,000
Twentymile (Cyprus Amax)	Wadge	96-114	102	840	17,600	600-1,300	36	Long-Airdox DDR	1,920
West Elk (Mt. Coal Co)	B	276	144	950	3,500-9,000	600-1,400	40	Joy 6LS DDR 1,720	15,000

Railroad in 1997. The 1999 production goal is 6 million tons.

In January 1998, the West Elk Mine had a water inflow problem from a fault system within development sections of the mine. Horizontal drilling down coal seams has reduced flow rates and production returned to full capacity. One new airshaft is online and two new ones were constructed in 1998 to ventilate the B and E coal seams. The 20-foot thick B seam is currently the only productive zone. West Elk hopes to mine the 13-foot E seam in the future, which would be an additional 100 million tons of 11,700+ Btu/lb. coal.

Production from the longwall mining operation at the Deserado Mine in Rio Blanco County increased substantially making Deserado the fifth highest coal producer in the state. The Deserado Mine supplies coal to the Bonanza power plant in Utah. Its 1998 production was 1.72 million tons, 10 percent greater than in 1997.

*Coal Outlook* reported in May 1996 that Peabody Coal Company is exploring the possibility of opening a new longwall mine, the Big Elk Mine, in Routt County to produce from 5 to 8 million tons of coal per year from the Wadge seam of the Mesaverde Formation. The mine could be operating soon after the year 2000 if Peabody continues with the project.

In the Cyprus Amax Twentymile Mine, problems associated with mining

in steep grades (10 to over 15 percent) during the first quarter of the year were overcome and productivity was resumed. Regulatory approval has been obtained by Cyprus Amax for the redesign of mine plans to increase both safety and productivity by better accounting for areas with steep dips. Despite this problem with steep grades, the mine increased production by more than a million tons.

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 1998. Rail traffic to the Somerset coal field would increase if the three mines there get permit expansion approval.

Cyprus Amax Minerals Company announced in late 1998 that it was selling its coal division, which include the Twentymile Mine in Routt County and the idle Empire Mine in Moffat County. Potential investors have expressed interest but no final transactions have occurred.

Colorado coal producers are facing tough competition from low-cost producers such as the large mines in the Wyoming Powder River Basin, which can produce coal in the \$6 to \$7 per ton range. Coal company profitability is under pressure from excess capacity, competition from natural gas, environmental regulations, and electricity industry deregulation.

The pressure to cut costs is great. The EIA stated that the average mine

price of U.S. coal in 1997 was \$18.14 per short ton, a drop of 2 percent from 1996. This was the 15<sup>th</sup> straight year of decline. The price of western coal has dropped an average of 2.5 percent per year in the last 15 years. In real dollars, the decline over this period was 5 percent per year. Without long-range contracts, Colorado coal has sold for as low as \$12 per ton.

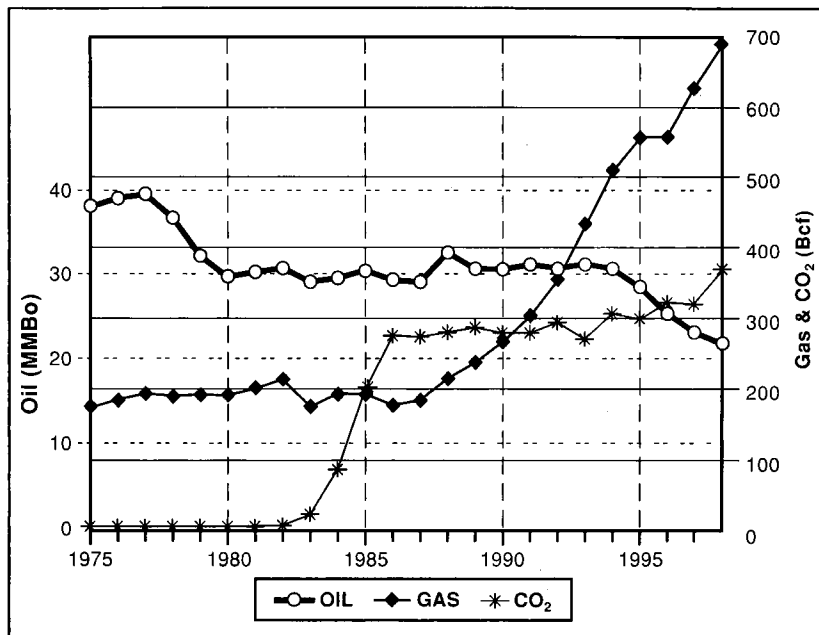
## OIL AND GAS

### Production

Colorado hydrocarbon production in 1997 totaled 24.4 million barrels of oil (MMBO) and 650 billion cubic feet (Bcf) of natural gas. Carbon dioxide production totaled 333.3 Bcf. In 1997, Colorado ranked 10<sup>th</sup> of all states in daily crude oil and lease condensate production with 66,764 barrels of oil (BO) per day and 7<sup>th</sup> in daily dry gas production with 1.78 Bcf per day. Consumption of natural gas in the state in 1997 was 305.9 Bcf. Accordingly, Colorado in 1997 consumed 47.1 percent of its produced volume.

Extrapolation of the state's 1998 January through October hydrocarbon and carbon dioxide production volumes provided by the Colorado Oil and Gas Conservation Commission (COGCC) suggests full year production figures will be 22.1 MMBO, 692 Bcf of natural gas, and 368 Bcf of carbon dioxide. The projected 1998 oil volume of 22.1 MMBO is a 9.4 percent decline from

**Figure 18.**  
Colorado annual oil, natural gas, and carbon dioxide production, 1975–1998. Note general rise in natural gas production and decline in oil production



1997. This continues the long-term slide in Colorado oil production that began in 1977. The projected 1998 gas volumes (natural gas and carbon dioxide), if correct, will establish new annual state production records for these commodities (Fig. 18).

Natural gas production in the southern Rocky Mountain region of Colorado, northern New Mexico, Utah, and Wyoming in 1987 totaled 1,021 Bcf. Regional volumes have risen every year since, reaching a new record of 2,759 Bcf in 1997. As a percentage of regional production, Colorado's natural gas production has risen in the same time period

from 15.6 percent to 24.6 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 subsequent steadily rising natural gas production, this volume has now increased approximately sixteen-fold, to 344.1 Bcf in 1997.

Colorado coalbed methane production in 1997 totaled 333 Bcf, which placed Colorado in second place in the U.S. behind New Mexico's 597 Bcf.

Coalbed methane production in Colorado in 1998 is expected to total 384 Bcf. This anticipated "new" record volume would represent just under 55.5 percent of the state's total gas production, up from a 51.3 percent contribution in 1997.

Nationally, coalbed methane production grew by about 9 percent in 1997 to 1,090 Bcf—about 6 percent of U.S. natural gas production. Most of the 1997 production increase (87 Bcf) occurred in the San Juan Basin of Colorado and New Mexico. Also noteworthy, is the growing production stream of coalbed methane from the Colorado portion (Las Animas County) of the Raton Basin of south central Colorado and northeast New Mexico. In 1996, Las Animas County produced 5 Bcf of gas. In 1997, the region produced nearly 11.8 Bcf of gas. In 1998, this volume should build to 19.4 Bcf, nearly a fourfold increase in just two years.

In 1997, Rio Blanco County led all Colorado counties in oil production (Table 7). The Rangely field's Weber Sandstone pool (Permian and Pennsylvanian age) produced 7,668,936 BO which provided 93.7 percent of the

**Table 7. Top three oil producing counties in Colorado in 1997 (BO = barrels of oil).**

Rating	County	Ann. Oil Prod., BO	Cum. Oil Prod., BO
1	Rio Blanco	8,183,812	921,323,041
2	Weld	7,420,356	177,113,272
3	Cheyenne	3,533,515	71,066,554



county total. Second and third place in county production went to Weld County and Cheyenne County. Wattenberg field'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 (76.6 percent).

The top three natural gas producing counties in 1997 were La Plata, Weld, and Garfield (Table 8). La Plata County's Ignacio Blanco field's Fruitland Formation coalbed methane reservoir (Late Cretaceous age) contributed 318.2 Bcf (90.3 percent) of La Plata County's

**Table 8. Top three natural gas producing counties in Colorado in 1997 (Mcf = thousand cubic feet).**

Rating	County	Ann. Gas Prod., Mcf	Cum. Gas Prod., Mcf
1	La Plata	352,248,824	2,608,949,576
2	Weld	108,702,980	1,900,955,191
3	Garfield	51,072,855	344,628,487

natural gas production. Wattenberg field provided just over 90 percent of the Weld County natural gas total. Weld County achieved a significant milestone in November 1998 by becoming the second county in the state to exceed 2 trillion cubic feet (Tcf) in cumulative natural gas production. La Plata County in 1996 was the first county in the state to achieve this milestone. Cumulative natural gas production at the end of 1998

in La Plata and Weld counties will stand at approximately 2.999 Tcf and 2.012 Tcf respectively. In the first week of 1999, or soon after, La Plata County cumulative natural gas production will pass 3 Tcf. Also of note in 1998 was that some time during November, the Shell Western E & P, Inc.-operated McElmo field in Montezuma County exceeded 3 Tcf in cumulative carbon dioxide production. The principal carbon dioxide reservoir in the McElmo field is the Mississippian age Leadville Limestone.

The producing well count in 1997 was 17,921. The break down by category was 82 carbon dioxide producers, 1,169 coalbed methane producers, and 16,670 conventional wells. Weld County led all counties in number of active wells in 1997 with a total of 8,744.

In 1997, 31 of Colorado's 63 counties were oil productive, 33 produced natural gas from conventional reservoirs, seven produced coalbed methane, and three produced carbon dioxide. Five fields account for all of Colorado's carbon dioxide production: Dike Mountain and Sheep Mountain fields in the northwestern part of Raton Basin in Huerfano County; McCallum and McCallum South fields in the northeastern part of the North Park Basin in Jackson County; and McElmo field in the eastern part of the Paradox Basin in Montezuma County. Two of these fields accounted for 99.2 percent of the 1997 Colorado carbon dioxide production stream: McElmo with 217.1 Bcf and

Sheep Mountain with 59.7 Bcf. There are 13 Colorado fields that produced coalbed methane in 1997 and approximately 1,100 fields that produced oil and/or natural gas from conventional reservoirs.

## Consumption

State natural gas consumption by sector in 1997 is listed below in Table 9.

In excess of 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 crude oil for 1996 by source is listed below in Table 10. Data for 1997 from the U.S. Department of Energy is not available at the time of publication.

**Table 9. Colorado natural gas consumption by sector in 1997.**

Sector	1997 Nat. Gas Consumption (Bcf)	Percent of Total Nat. Gas Production
Residential	115.6	17.8
Industrial	73.8	11.4
Commercial	69.1	10.6
Lease, pipeline, & plant fuel	41.9	6.4
Electric utilities	5.5	0.9
Export out of state	344.1	52.9
<b>Total</b>	<b>650.0</b>	<b>100.0</b>

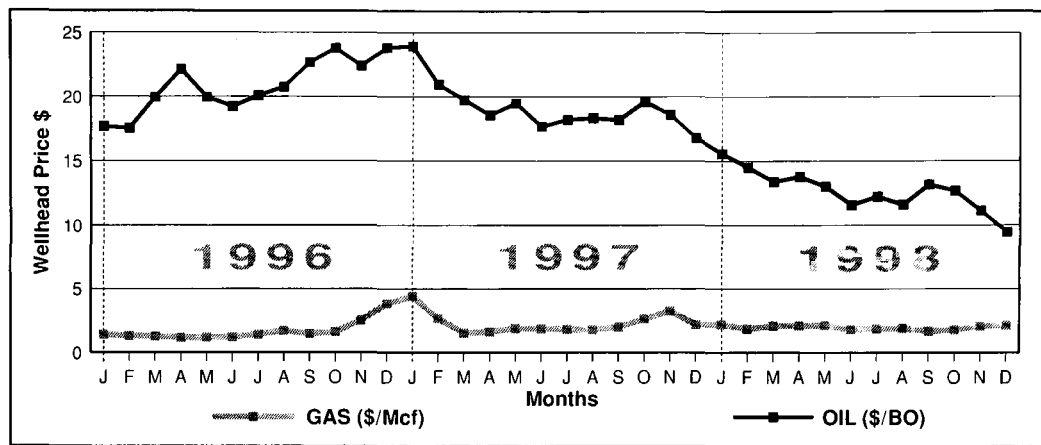
Colorado crude oil production in 1996 totaled 25,642,998 barrels. Accordingly, in 1996, consumption of refined crude oil products in Colorado was almost three times the state's oil production.

**Table 10. Colorado consumption of refined crude oil by source in 1996.**

Type of Use	1996 Consumption in Barrels	Percent of Total Consumption
Asphalt and road oil	3,904,000	5.6
Aviation gasoline	124,000	0.2
Diesel	14,839,000	21.1
Jet fuel	7,765,000	11.0
Kerosene	33,000	0.05
Lubricants	608,000	0.9
Motor gasoline	43,028,000	61.2
Residual fuel	20,000	0.03
<b>Total</b>	<b>70,321,000</b>	<b>100.08</b>

## Value and Pricing

The total value in 1998 of oil, gas, and carbon dioxide production in Colorado was \$1,714 million dollars: oil \$280 million, natural gas \$1,349 million, and carbon dioxide \$85 million. The total value in 1997 for these commodities in Colorado was \$2,026 million dollars: oil \$460 million, natural gas \$1,489 million, and carbon dioxide \$77 million. The 1998 \$319 million dollar drop in production value as compared to 1997 was a result primarily of lower wellhead oil prices and lower gas prices. Figure 19 shows



**Figure 19. Colorado oil and gas monthly wellhead price index for 1996 through 1998. Data from Colorado Oil and Gas Conservation Commission files.**

the Colorado oil and gas monthly wellhead price index for 1996 through 1999.

The average annual wellhead price in Colorado for oil decreased by 33.3 percent from \$18.89 in 1997 to \$12.65 per BO in 1998. The average wellhead price for gas in the state decreased 14.8 percent from \$2.29 per Mcf in 1997 to \$1.95 per Mcf in 1998. The wellhead price for carbon dioxide remained flat at \$0.23 per Mcf during 1998 as compared to 1997. Figure 20 shows 1997 Colorado oil, natural gas, and carbon dioxide production value by county. Ten of Colorado's 63 counties generated over \$20 million in 1997 production value of oil and/or gas. Production values for 1998 for the state's individual counties were not available at the time of this writing.

## Drilling Permits

In 1998, 1,310 permits were processed by the COGCC (1,157 drilling and 153 re-completion). This compares to 1,002 drilling permits and 124 re-completion permits processed in 1997. The five counties that led in 1998 permit applications were Weld (392), Las Animas (195), Yuma (111), Garfield (95), and La Plata (82). Weld County also led in 1997 with 285 permits. Las Animas County moved up to second place from third place in 1997 as a result of accelerated development of coalbed methane from Late Cretaceous Vermejo Formation coal seam reservoirs. Yuma County moved up from fourth place in 1997 to third place in 1998 as a result of continued active development of biogenic natural

gas reserves from Niobrara Formation chalk reservoirs (Fig. 21).

Daily rig counts were down significantly in 1998 to an average of 12.8 from 16.3 in 1997. This drop of 21.5 percent in Colorado is nearly double the U.S. percentage drop in 1998 drilling compared to that in 1997. Daily average of rotary

rigs working in the U.S. during 1998 (land, inland waters, and offshore), was 831.

Table 11 is the final list of the Colorado oil and gas wildcat discoveries in 1997 and a preliminary list of the state's 1998 oil and gas discoveries. This data has been derived from COGCC files. Figure 22 locates these wells in map view.

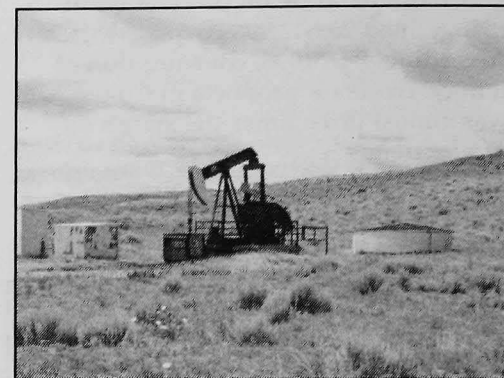


Figure 21. J-W Operating Company gas well, Eckley field, Yuma County. The Conrad I-31 well, one of the better wells in the field, was completed in July 1980 from perforations at the top of the Niobrara Chalk from 2,604 to 2,631 feet. The Conrad well has a December 1998 cumulative production of nearly 898 MMcf. Eckley field is the largest field in Colorado producing from the Niobrara Formation chalk reservoir. Eckley field has a cumulative December 1998 production of 40 Bcf from 91 wells.

## Reserves

Proven crude oil reserves in Colorado at the end of 1997 were 198 MMBO, down from 231 MMBO at the end of 1996. Proven dry natural gas reserves at the end of 1997 were 6,828 Bcf, down 882 Bcf from the 1997 total of 7,710 Bcf. The 1997 figures put Colorado in 11<sup>th</sup> place among the fifty states (excluding federal offshore) in crude reserves and 8<sup>th</sup> place in dry natural gas reserves (excluding federal offshore).

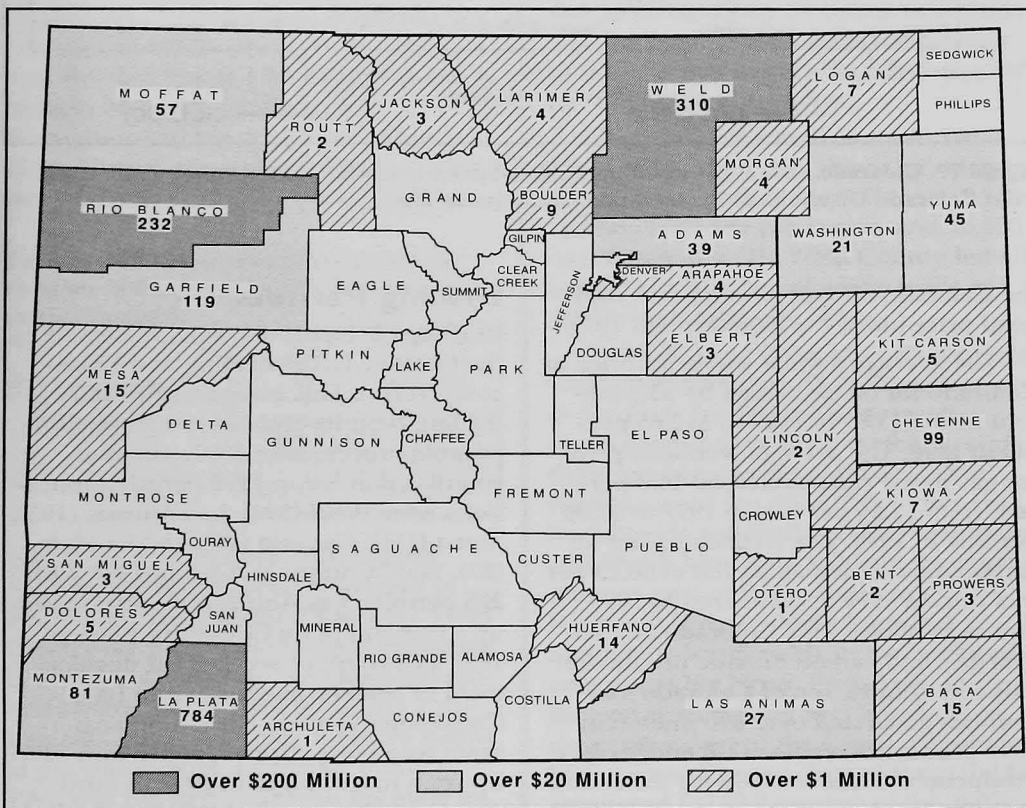


Figure 20. Colorado county oil and gas production values, 1997 (in millions of dollars). Data from Colorado Oil and Gas Conservation Commission files.

**Table 11. New oil and gas fields discovered in 1998. (See Fig. 22.)**

Map No.	Field Name	Sec.	Twp.	Rge.	PM	County	Pay Zone	Initial Potential		
1	Aztecan	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

Dry natural gas reserves in Colorado as reported by the Energy Information Administration (EIA), the independent statistical and analytical agency within the U.S. Department of Energy, had increased every year at an average of 18

percent per year from 1987 to 1996. The rather sharp fall in Colorado dry natural gas reserves as reported by the EIA in 1997 was the result of a combination of downward revisions by the agency and unreplaced production.

The EIA, however, believes the stage is set for a future increase in Colorado reserves due to a strategic acquisition by operator HS Resources. Near the end of 1997 HS Resources acquired Amoco's Denver Basin properties for \$330 million. This acquisition capped a program by HS Resources that spanned many years of acquiring producing and undeveloped properties in and surrounding the basin's large Wattenburg field. For HS Resources, the compelling reason for the acquisition was the extraordinary abundance of reserves that could be unlocked by combining the Amoco properties with its own. For example, in many instances, HS Resources owns the right to produce from formations which are "behind pipe" in an Amoco producing well. Bringing these reserves into production by recompleting an existing well generates substantially better economics than can be achieved by drilling a new well. In other instances, Amoco owned the right to produce from formations located deeper than horizons from which HS Resources was already producing, and deepening an existing well is substantially more economic than drilling a new well. Without these efficiencies, much potential proved reserves were economically "stranded" because drilling a new well could not be justified. The re-aggregation of reserves and value created by the Amoco divestment gives HS Resources a substantial inventory of projects with virtually no geologic risk and exceptional rates of return if

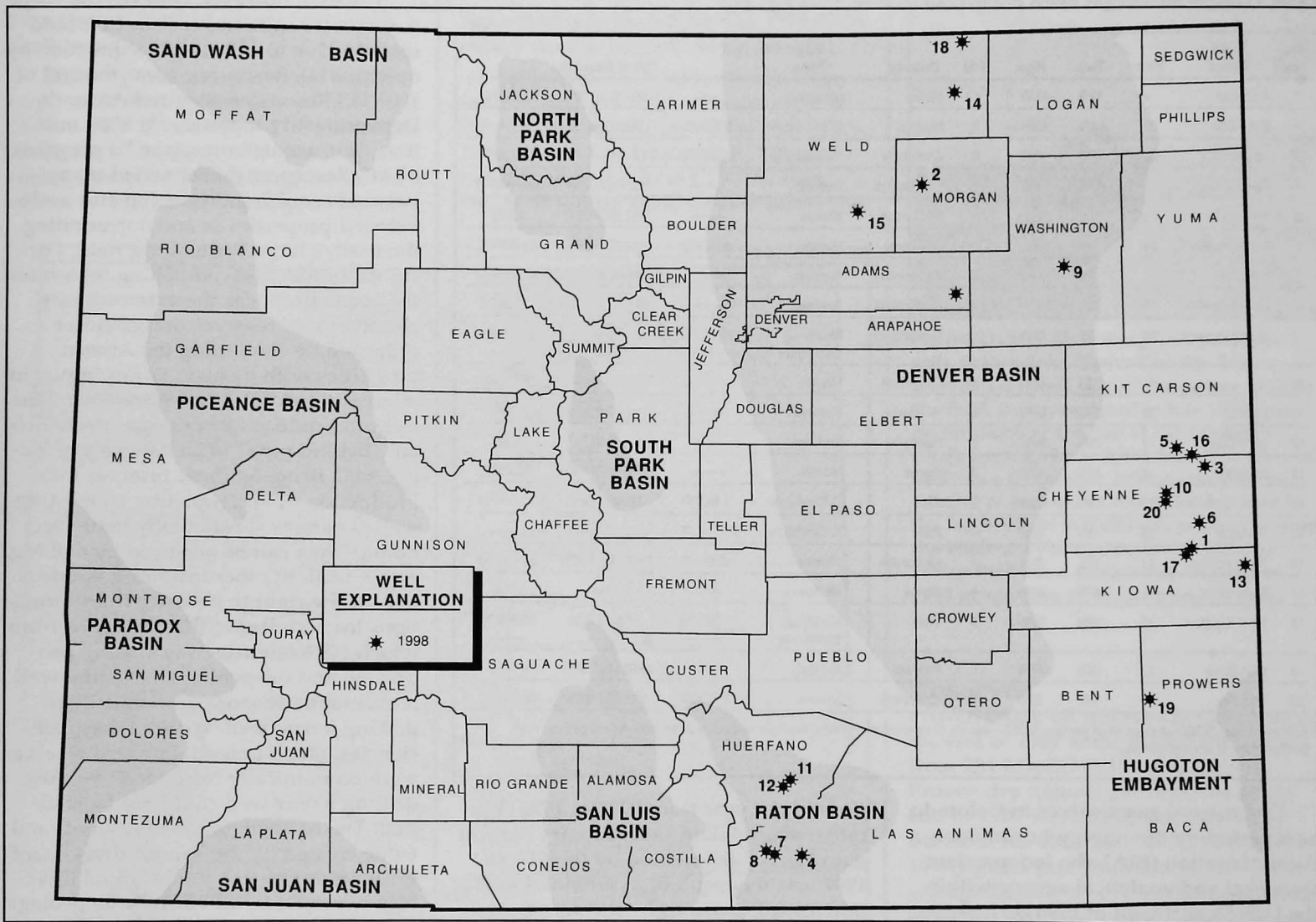


Figure 22. Location map of 1998 wildcat oil and gas discoveries in Colorado. See Table II for name and date. Data from Colorado Oil and Gas Conservation Commission files.

gas prices remain stable in this gas prone fairway.

## News and Developments

### Falling Oil Prices

Dominating the news about the energy industry in Colorado, the Rocky Mountain Region and the U.S. during 1998 was impacted by the plunge of oil prices, which eroded steadily throughout the year. The American Petroleum Institute recently stated that U.S. well-head prices in November 1998 for oil averaged less than \$10 per BO, the lowest level in more than 50 years, when adjusted for inflation. Mr. Richard Griebeling, Director of the COGCC, in a January 11, 1999 letter to COGCC commissioners, pointed out that the Colorado Oil Price Composite Index, as calculated by COGCC, reached \$9.46 per BO in December. Mr. Griebeling stated this is the first time this index, which COGCC has maintained since July 1992, has fallen below \$10 per BO.

The outgoing chairman of the Interstate Oil and Gas Compact Commission (IOGCC), Governor Jim Geringer of Wyoming, recently released a IOGCC report which painted a picture of an industry in trouble: wells are being shut-in, domestic production is falling, jobs are disappearing, and still deeper cuts are expected in exploration and development drilling. According to Governor Geringer, the vast majority of oil-producing states have seen income

from oil production cut in half, which not only negatively impacts operators but also royalty owners and state and federal tax revenues.

The Independent Petroleum Association of Mountain States mailed a questionnaire to its association members in December 1998 on how the drop in oil prices had affected their operations. This unscientific survey compiled from the responses of 35 small to midsize Rocky Mountain independent energy companies reported that:

- Revenues losses since January 1, 1998 were estimated at almost \$2.5 million per month.
- Exploration budgets had been slashed by \$135.6 million in 1999.
- 144 layoffs had occurred since January 1, 1998. 58 more layoffs were expected in 1999.
- Anticipated oil production reductions due to shut in wells were estimated at 777,796 barrels in 1999.
- Oil production was slashed by 3,199 barrels of oil per day since May 1998.

One of the energy company corporate strategies that has developed to cope with falling profits has been to arrange mergers. Caught up in this trend was Colorado's largest producer of natural gas and sixth largest producer of oil, Amoco. In September 1998, Amoco announced its merger with British Petroleum Company. Then in November 1998, Amoco, citing "tremendous cost

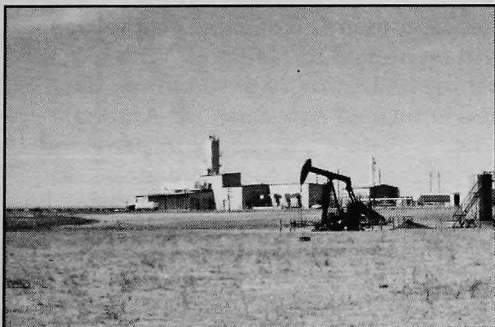
pressure resulting from the depressed price environment coupled with an increasingly competitive marketplace", announced it would consolidate its U.S. exploration and production management offices to Houston and close its Denver office. Amoco's Denver exploration and production office at the time of the announcement had about 380 exploration, production, and support employees. Less than 100 of these employees will be moved to Houston. With a market capitalization of \$140 billion, the newly formed company, BP-Amoco p.l.c., is Britain's biggest company and one of the world's top three major oil companies. For the time being, BP-Amoco p.l.c. will continue to operate its producing properties in the Ignacio-Blanco field in the San Juan Basin of southwestern Colorado.

### New Projects

Union Pacific Resources Company, in April 1997 disclosed plans to invest \$100 million in east-central Colorado to develop several natural gas fields that contain high concentrations of helium (up to 4 percent). The fields are located on the northern end of the Las Animas Arch near Cheyenne Wells, Colorado. The reservoirs are Pennsylvanian Morrow Formation channel sands at a depth of approximately 5,000 feet.

In addition to development drilling, the project entailed the construction of a gathering and compression infrastructure, a natural gas processing plant, and

a helium liquefaction facility. Union Pacific Resources completed construction of the processing facility, Ladder Creek Helium Plant (Fig. 23), in the late summer of 1998. The Ladder Creek plant is located just southwest of Cheyenne Wells, about 152 miles southwest of Denver.



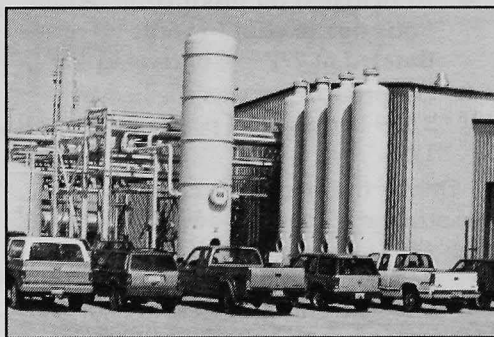
**Figure 23. Ladder Creek Helium Plant southwest of Cheyenne Wells, Cheyenne County, Colorado.**

According to Union Pacific Resources, the plant is the 10<sup>th</sup> in the nation and the 12<sup>th</sup> in the world capable of producing liquefied helium (Fig. 24). The boiling point of helium is  $-451.48^{\circ}\text{F}$ . The plant is designed to take the pure helium liquid down about  $7.5^{\circ}$  lower to  $-458^{\circ}\text{F}$ , which is only about  $1.5^{\circ}\text{F}$  above absolute zero ( $-459.67^{\circ}\text{F}$ ).

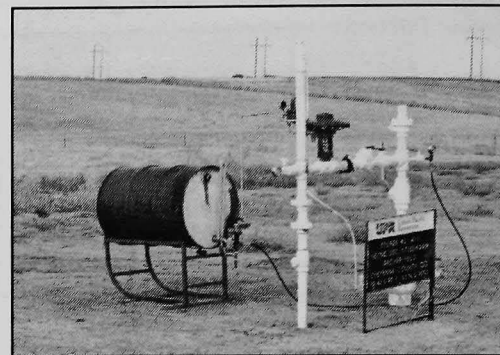
The Ladder Creek plant, which shipped its first liquefied helium on October 12, has a long-term, \$6 million

annual contract to sell up to 150 million cubic feet of liquid helium.

Currently, the plant is processing 30 million cubic feet of gas a day. About 50 percent of the volume from the Morrow Formation supply wells is nitrogen, 25 percent is hydrocarbon gases, 21 percent is carbon dioxide and the remaining 4 percent is helium (Fig. 25). The carbon dioxide and nitrogen is separated at the plant and vented to the atmosphere. The lightest hydrocarbon gas, methane, is compressed and sold into a pipeline, which transports this gas east to mid-western markets. The heavier hydrocarbon gases, ethane, propane, and butane, after separation, are sent via a 4-inch pipeline 40 miles north to Burlington to connect into a six inch Amoco pipeline which moves these products to eastern markets. The Amoco line's main gas



**Figure 24. Ladder Creek Helium Plant. The four upright tanks in the right foreground are used for processing pure helium gas that has been cooled to the light gas's boiling point of  $-451.48^{\circ}\text{F}$ .**



**Figure 25. Union Pacific Resources helium gas well for the Ladder Creek Helium Plant, Archer Field, Cheyenne County. The Pfeifer #2 41-5 was completed in December 1997 and placed on line to supply the helium plant in September 1998. The well produces from Morrow perforations at 5,284 to 5,292 feet. During December 1998 the Pfeifer well was flowing about 950 Mcf of low Btu gas to the Ladder Creek Helium Plant.**

supply is from Wattenberg field processed gas. Point of origin of the Amoco line is in the Fort Lupton area, located a few miles north of Denver.

According to the *Denver Post*, the uses for helium include: cooling super conducting magnets in the medical magnetic resonance imaging machines used by hospitals to detect tumors and other problems; to helping cool nuclear reactors; using a gas for supersonic wind tunnels; and use in the manufacturing of fiber-optic strands. Deep-sea divers use a mixture of helium and oxygen. Helium is also used for pressuring

liquid fuel rockets and filling drugstore balloons and airships such as the Met-Life's Snoopy 2, which provides TV coverage at major sport venues.

## 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. Prices for uranium oxide have since settled in the \$10 to \$11 range. Cotter Corporation's Schwartzwalder Mine produced about 500,000 pounds of uranium oxide in 1998. 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 within a

Precambrian garnet-biotite gneiss and quartzite unit.

The ore is trucked to a stockpile at Cotter's Canon City mill, which is undergoing a major refurbishment and is expected to be in operation early in 1999.

Cotter conducted exploration drilling in 1998 on some of its properties in the Uruan district of southwestern Colorado. Because of low prices and the decision to sell the company, Cotter has ceased all exploration and development activities at the Schwartzwalder Mine. Mining will continue in the developed areas of the mine through part of 1999.

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 1998 is estimated at 54,000 tons of ore at an average grade of 0.26 percent  $U_3O_8$  and 1.7 percent  $V_2O_5$  equaling 280,000 pounds of  $U_3O_8$  and 1,836,000 pounds of  $V_2O_5$ . The ore is trucked to the company's White Mesa Mill in Blanding, Utah.

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.

According to the U.S. Geological Survey Mineral Information Office, the average price for  $V_2O_5$  in 1998 was \$4 per pound. The total value of the produced uranium in the state is \$8 million. The vanadium has an estimated value of about \$7 million.



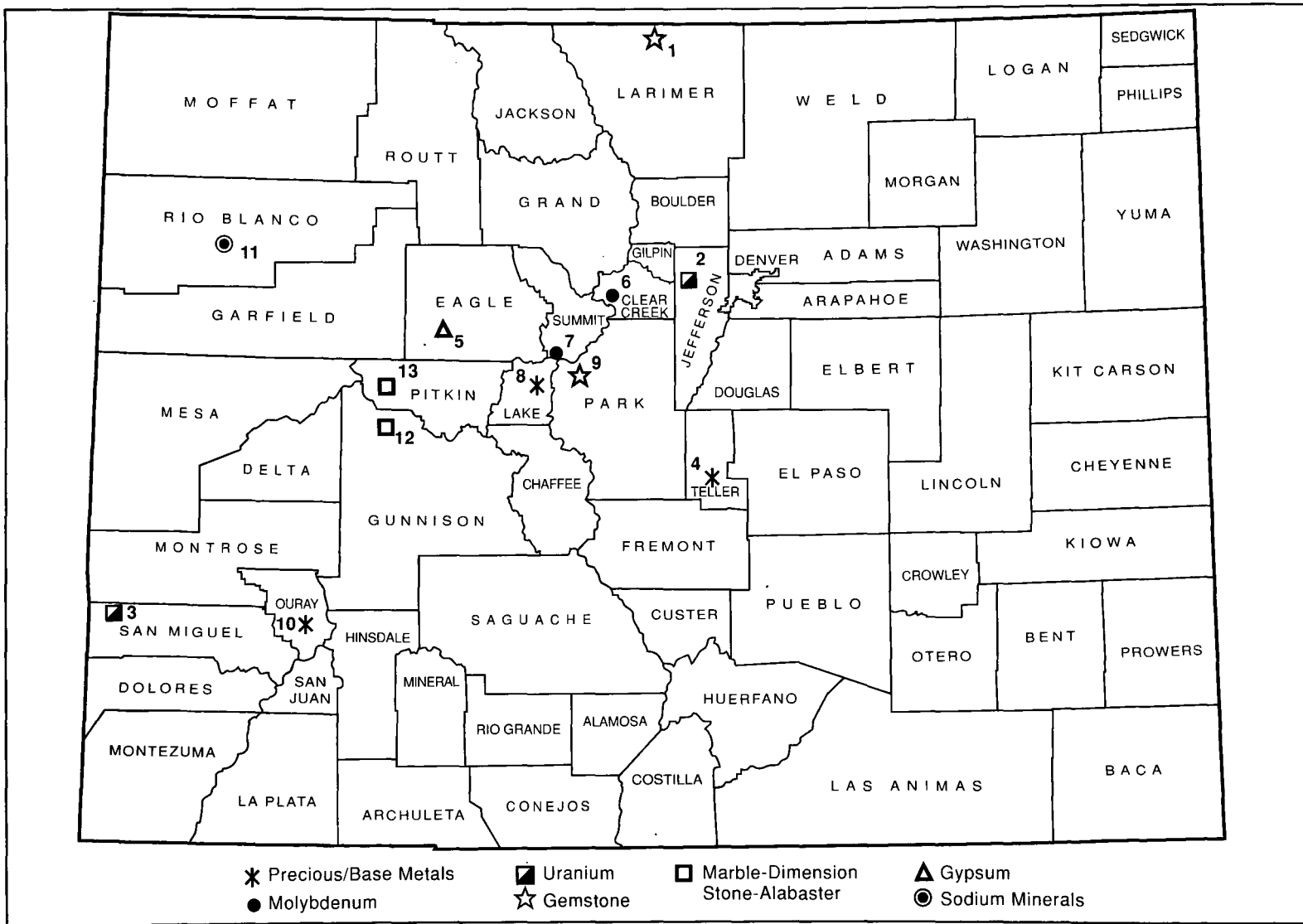


Figure 26. Map showing location of major mineral producers and prospects in Colorado

## 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. 26 and Table 12 for a location map and brief description of all the metal mines in the State). In 1998, the mine produced 30.1 million pounds of contained molybdenum from about 6.9 million tons of ore (Fig. 27). The 1998 production is down substantially from the 1997 level of 37 million pounds. According to the U.S. Geological Survey Mineral Information Office, the 1998 average price for contained molybdenum is \$3.86 per pound. The estimated total value of the produced molybdenum from the Henderson Mine in 1998 is \$116 million. The Henderson mine and mill complex employs approximately 460 people.

The company is continuing with its modernization program, Henderson 2000. The program consists of replacement of the 10-mile underground train haulage system from mine to mill by a 10-mile-underground conveyor belt. Ore

crushing facilities will be moved from the mill to an underground site at the mine. A new 7,175-foot production level will be developed that enables the extraction of the lower portion of the ore body. 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. The project is scheduled for completion in 2000.

### Gold and Silver

The precious metal industry in Colorado

**Table 12. Table of major mineral producers and prospects in Colorado, numbers refer to Figure 26: 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 Conststruction Prod.
6	Henderson	Molybdenum	UG	Cyprus Amax Minerals Co.
7	Climax	Molybdenum	UG, OP	Cyprus Amax Minerals Co.
8	Black Cloud	Zinc, lead, gold, silver	UG	Asarco, Inc.
9	Sweet Home	Rhodochrosite	UG	Sweet Home Rhodo, Inc.
10	Revenue-Virginus	Gold and Silver	UG	Sunshine Mining & Refining Co.
11	White River	Sodium bicarbonate	SOL	White River Nahcolite Co.
12	Yule Quarry	Marble	UG	Colorado Yule Marble Co.
13	White Banks	Alabaster, marble	UG	Crystal Valley Mining Co.

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

set a modern era (post World War II) production record in 1996 with approximately 250,000 ounces of gold and

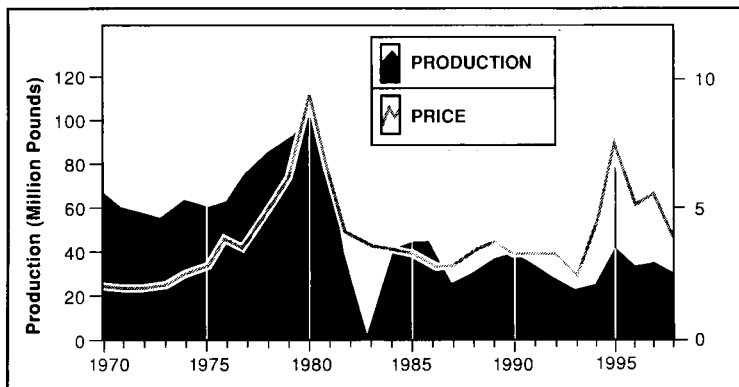


Figure 27. Colorado molybdenum production and price.

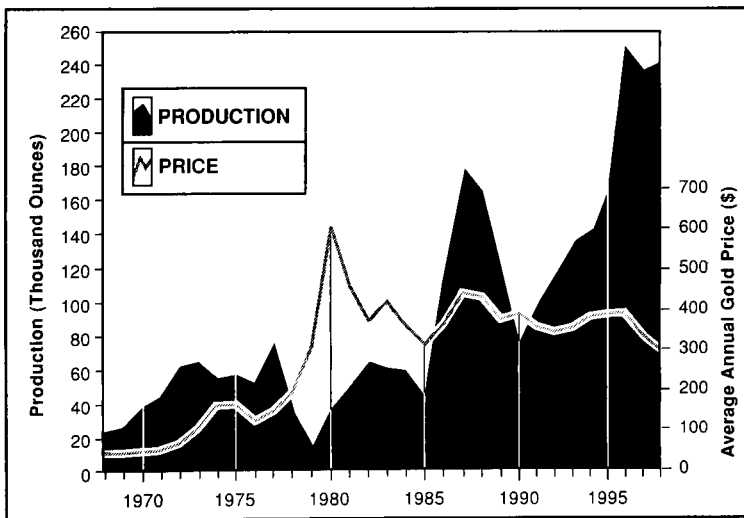


Figure 28. Colorado gold production and price.

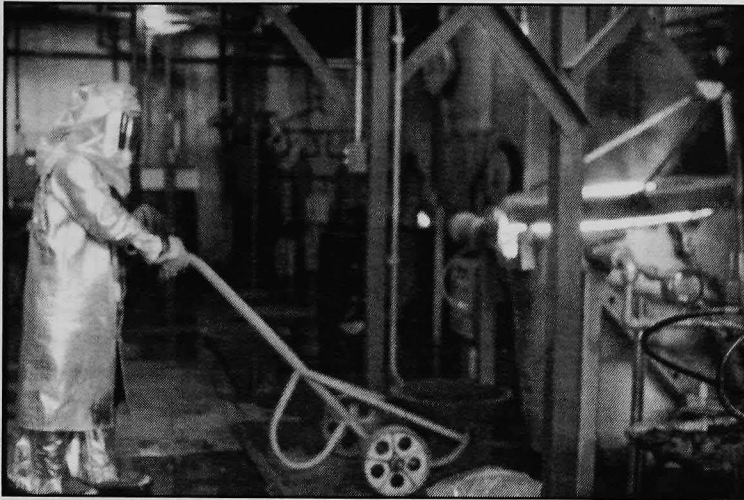
312,000 ounces of silver (Fig. 28). Gold production in 1997 declined six percent to an estimated 236,000 ounces of gold.

Silver production in 1997 rose to 410,000 ounces. Gold production in Colorado in 1998 came from two mines, the Cresson Mine and the Black Cloud Mine, and was stable at approximately 236,000 ounces of gold. Silver production declined to 256,000 ounces.

The Cripple Creek and Victor Gold Mining Company continued mining and leaching operations at the Cresson Mine in the famed Cripple Creek district, Teller County (Fig. 26 and Table 12). The Cresson Mine has a proven and probable reserve of 127 million tons at a grade of 0.027 ounce of gold per ton for a total of 3.4 million ounces. Production at the Cresson Mine for 1998 is estimated at 230,000 ounces of gold and 81,000 ounces of silver.

The Cripple Creek mining district is located within a Tertiary (32 million years old) alkaline volcanic-diatreme complex, which was intruded into Precambrian granites and metamorphic rocks. Gold mineralization is found in quartz and telluride veins and as disseminated low-grade deposits in a phonolite breccia. Bob Womack discovered gold in the district in 1891 and by the early 1900s, Cripple Creek was a boomtown with a population of over 60,000 people. Most of the underground mines in the district were producing high-grade ores with grades averaging approximately two ounces of gold per ton. To date, the district has produced over 21 million ounces of gold, about half the total production for the entire state of Colorado.

The present rate of production from the open pit at the Cresson Mine is 26,000 tons of ore and 45,000 tons of overburden per day. After blasting, the ore is transported by haul trucks to a gyratory crusher. Lime is added to the crushed ore for leach solution alkalinity control and the ore is then transported by truck to the heap leach pile. A solution with a concentration of 20 to 40 parts per million cyanide is applied to the heap. As the barren solution passes through the crushed ore, it dissolves the gold in the ore and becomes "pregnant." The pregnant solution passes through a carbon adsorption plant where 95 percent of the gold in the pregnant solution is adsorbed onto



**Figure 29. Gold pour at the Cresson Mine, Cripple Creek district, Teller County. Molten gold pours from the furnace into the wheeled cart that has a cone-shaped mold. When cooled and solid the mold is inverted and a doré is produced.**

carbon. The loaded carbon then goes to a strip circuit where the gold is dissolved into a special sodium solution, which then goes to an electrowinning circuit where the gold is deposited on steel wool cathodes. The gold is removed from the steel wool cathode by pressure washing, melted in a furnace, and poured into large 50 to 60 pound buttons called a "doré" (Fig. 29). The doré produced at the Cresson Mine contains about 75 to 80 percent gold and 20 to 25 percent silver. All materials and solutions used in the electrowinning are stripped of dissolved metals and other compounds and recycled back into the recovery process.

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.

Earlier this year the company announced plans 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.

The Cripple Creek and Victor Gold Mining Company is partially owned by Independence Mining Co., a wholly owned subsidiary of Minorco. Anglo American Corporation of South Africa is acquiring Minorco's North and South American precious metal assets for a reported \$550 million.

Precious metals are produced as a by-product of base metal mining at the Black Cloud Mine in the Leadville district. In 1998, the Black Cloud Mine produced an estimated 6,000 ounces of gold and 175,000 ounces of silver.

ITEC Environmental has begun reprocessing tailings from old mines in

the area around Gold Hill in Boulder County. The company acquired the Gold Hill Mill site and an additional 700 acres of old mining properties in the area. ITEC estimates that there is about one million tons of re-minable material on its properties. The tailings at the Gold Hill Mill range in grade from 0.13 to 0.15 ounce per ton gold, according to ITEC. After reclamation of the old tailing sites, the company plans to sell the land for commercial, residential, or public open space use.

### **Base Metals**

Asarco's Black Cloud Mine near Leadville (Fig. 26 and Table 12) is an underground room and pillar mine with a daily production capacity of 875 tons. The ore body is a complex massive sulfide 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. Estimated amounts of base metal production are 3,000 tons of lead, 9,000 tons of zinc, and minor copper.

In December 1998, Asarco announced that it would shut down production at the Black Cloud Mine leaving only a small maintenance and exploration crew. The mine began production in 1969 and was the largest private employer in Leadville. The company stated that low metal prices and exhaustion of minable reserves led to the decision to cease

production. 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.

## CONSTRUCTION MATERIALS AND INDUSTRIAL MINERALS

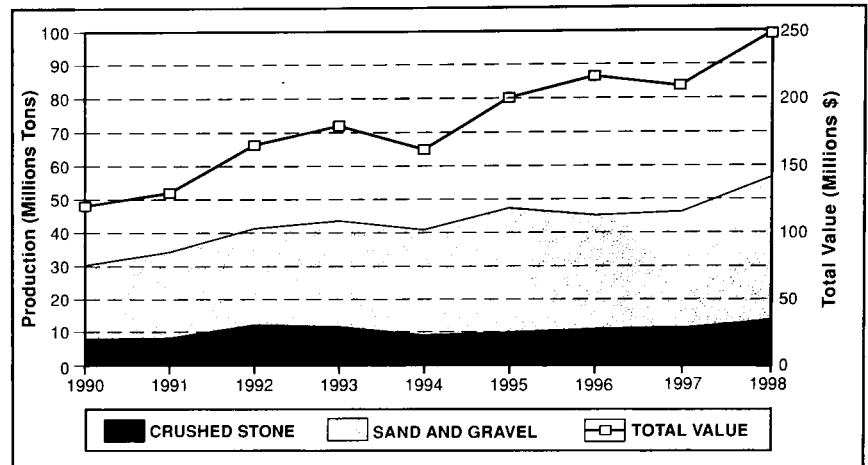
### Introduction

The most economically significant segment of the construction material industry in the state is sand and gravel and crushed stone. Other important construction 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 1998 but not discussed in this report include peat, bentonite clay, common clay, and kaolin.

### Sand, Gravel, and Aggregate

The sand, gravel, and crushed stone industry produced approximately 55 million tons of material in 1998, up 20 percent from the 46 million tons in 1997. The value of the 1998 production is estimated to be \$250 million (Fig. 30). Continued residential building in Colorado, especially in the Front Range counties, is largely responsible for the growth in construction material production.

**Figure 30.**  
Colorado  
crushed  
stone, sand  
and gravel  
production  
and price.



### Silica Sand

Colorado Silica Sand Inc. of Colorado Springs produces approximately 200,000 tons a year of specialty sand that is used for 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

The Colorado Yule Marble Company has been mining white marble from the historic Yule Marble Quarry near Marble, Colorado since 1992. In 1998, Peter Carroll of Bath, England purchased a \$8 million debtor note on the Colorado Yule Marble Company from

U.K.-based Hambro Bank, which halted foreclosure proceedings in Gunnison County Court. Carroll is now restructuring the business interest of the Colorado quarry as part of his Anglo-American Marble Company.

The White Banks Alabaster Mine was granted a mining permit from Pitkin County in April 1998 ending a seven-year struggle by the owner, Robert Congdon, to begin a mining operation. Congdon received State and Federal mining permits in 1991. The underground mine will develop an alabaster and black marble deposit in the Pennsylvanian Belden Formation. The black marble is noted for its hardness and multicolored veinlets.

### 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. Since that announcement, the mine has been operating at a much-reduced level. A lawsuit against Redaurum and Colorado Diamond Co. by Union Pacific Land Resources over ownership of the mineral rights was settled. Court documents concerning the settlement were sealed.

The Sweet Home Mine, an old silver prospect, in Park County was reopened as a rhodochrosite mine in 1991. Over the past 6 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 dollars.

## **Gypsum**

The Centex American Gypsum Corporation produced 410,000 tons of gypsum in 1998 from its open pit gypsum mine and plant in Gypsum, Eagle County. That figure is an increase of 11 percent over the 1997 production of 370,000 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. The company will be completing a 2-year production expansion program this summer that will result in a capacity increase to 550,000 tons per year.

## **Cement**

Holman Inc. is planning to build a \$200 million addition to its existing cement plant in Florence in order to meet increased demand because of Colorado's strong economy. The expansion will more than double the plant's capacity to about 2 million tons per year. A cement company from Mexico, Grupos de Cemento de Chihuahua, announced that it plans to build a new cement plant in the economic enterprise zone south of Pueblo. Both the plant addition and the new plant will add about 2.2 million tons of capacity to the state. Industry experts estimate that Colorado cement demand will be about 2.5 million tons in 1999.

## **Sodium Minerals**

The White River Nahcolite Company produced approximately 80 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 ACTIVITIES**

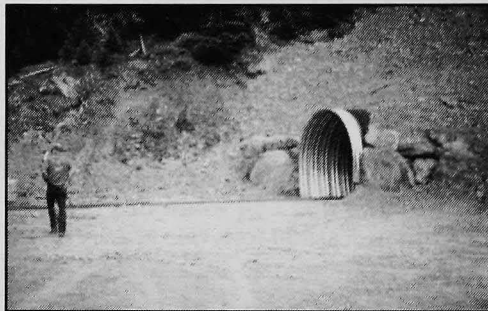
Sunshine Mining and Refining Co. is conducting pre-feasibility studies of the high grade silver deposit at the Revenue-Virginus Mine in Ouray County. The Revenue-Virginus Mine is estimated to contain 6.2 million ounces of silver within 260,000 tons of ore at a grade of 24 ounces per ton silver, 0.6 ounces per ton gold and a combined 5.9 percent copper, lead, and zinc. Historically, the Virginus 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. In 1998, Sunshine completed rehabilitation of the entry of the main adit (Fig. 31). Sunshine plans more exploration drilling on its claims and a program of metallurgical testing.

Royal Gold Inc. of Denver ended its exploration program for diamonds on the Union Pacific Resources land in the State Line district of Colorado and Wyoming. The company has no further

plans to explore or develop prospects in this area. Royal Gold's agreement with Union Pacific covered over 50,000 acres of land in the district

Summo USA Corporation had two sediment-hosted copper prospects in Colorado: the Cashin prospect in Montrose County and the Copper Spur prospect in southern Routt County. The company relinquished its claims at the Cashin prospect in order to focus on its Lisbon Valley copper project in Utah and a recent acquisition, the Johnson Camp in Arizona.

American Soda Company of Glenwood Springs announced plans for a solution-mining project for nahcolite in the Piceance Basin in Rio Blanco County. 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,



**Figure 31. Portal of Revenue Virginius Mine, Ouray County.**

Colorado. A 42-mile pipeline will transport the pregnant solution to a redesigned Unocal oil shale plant north of Parachute for processing and packaging.

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 a continuous exploration-drilling program during 1998. Some of the recent core holes have intercepted a new gold-bearing breccia

zone that parallels the past productive No Name vein. Preliminary data indicate that the breccia zone may be up to several thousand feet in length with widths up to 50 feet. Gold in the breccia zone is associated with iron, copper, lead, and zinc sulfides, and one or more silver minerals.

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  $TiO_2$  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  $TiO_2$ . 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.