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Colorado Mineral and Mineral Fuel Activity, 1996

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Colorado Geological Survey
Department of Natural Resources
Denver, Colorado
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Frontispiece: 1) Dragline operating at the Trapper Coal Mine, Moffat County. 2) Amoco Production Co. well in Spindle Field, Denver Basin. This is a Sussex Sandstone oil well. Longs Peak in Rocky Mountain National Park is in the background. Photo by Jennie Hemborg.



INTRODUCTION AND ECONOMIC FACTORS

The Colorado Geological Survey Mineral and Mineral Fuels Section estimates the total value of 1996 mineral fuel production in Colorado to be \$1,759 million dollars. The value of the coal production is estimated to be \$321 million, oil at \$537 million, natural gas at \$856 million, and carbon dioxide at \$45 million. Natural gas production in the state reached a new record of 556 billion cubic ft (BCF) in 1996. Oil production continued its

gradual decline. Prices for natural gas and crude oil increased during the year, offsetting some of the crude oil production decline. Coal production declined slightly from the record 1994 level. The contract cost for a ton of coal continues to go down as productivity rises.

Colorado's mineral production in 1996 is estimated by the U.S. Geological Survey at \$528 million, down 7 percent from the 1995 value of \$570 million. The

decrease in value is due to lower molybdenum production and prices, and the temporary closure of the Black Cloud Mine in Leadville. Sand and gravel, aggregate, construction clay, and gypsum all increased production in 1996. The total value of both mineral and mineral fuel commodities produced in the state during 1996 is \$2,287 million (Fig. 1).

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 to \$32.4 million in 1996 from a high of \$54.7 million in 1991. 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 complete water projects. Legislation passed in 1996 allows some of the state share of severance tax

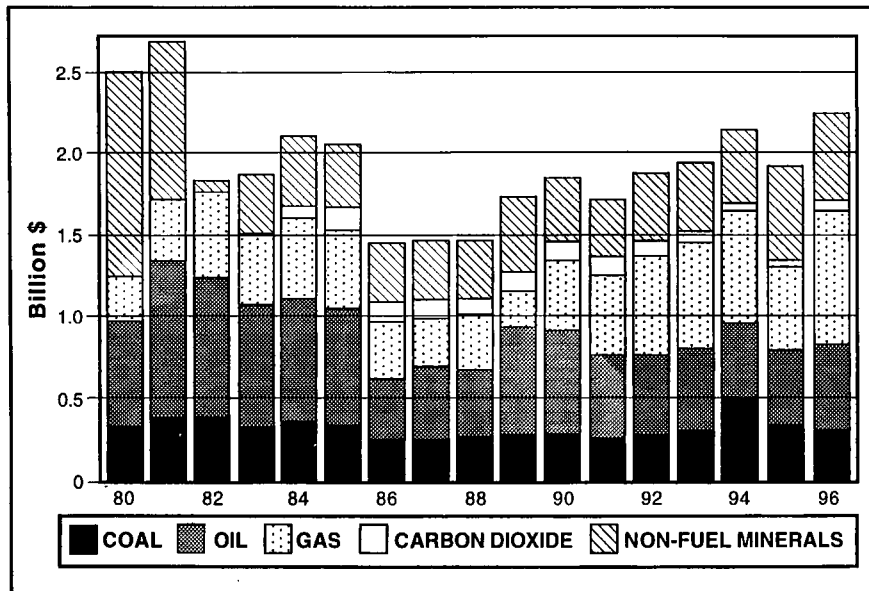


Figure 1. Value of Colorado mineral and mineral fuel production.

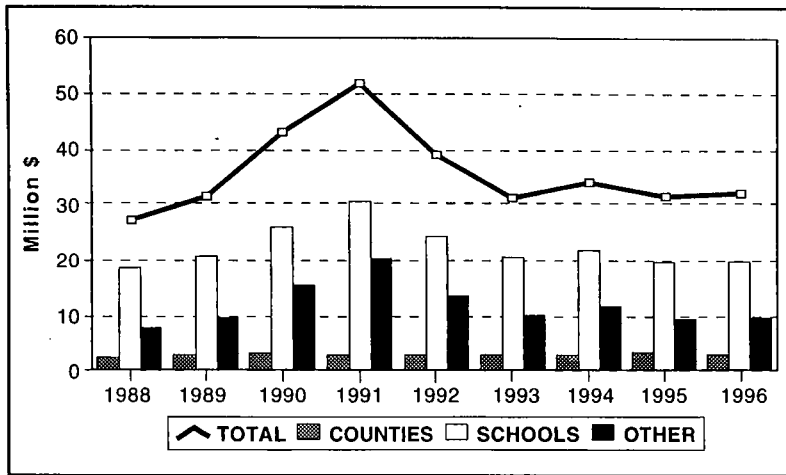


Figure 2. Federal mineral lease revenue distribution in Colorado.

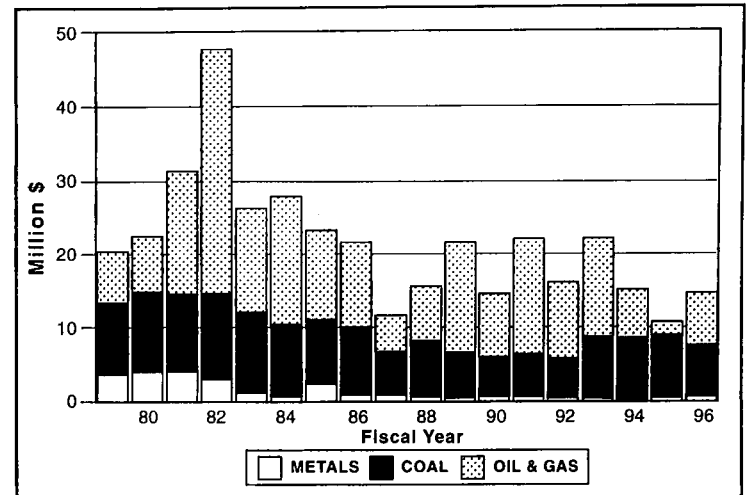


Figure 3. Colorado severance tax collections.

to be used by agencies within the Department of Natural Resources that promote and regulate the mineral and mineral fuel industries. Severance tax collections for the past five years have varied between \$12 million and \$22 million (Fig. 3).

Estimated property taxes paid in 1996 to the counties from mineral and mineral fuel properties totaled \$128.9 million (Fig. 4). La Plata, Weld, and Clear Creek counties all received over \$10 million each in 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 the employment in the mineral and mineral fuel industries in 1996 to be 15,500, down 0.6 percent from the 1995 level of 15,600. This sector of the economy continues a steady ten year decline in employment from a 1986 level of 25,800 persons. However, the average annual wage of \$46,000 of the mineral and mineral fuel industries is high in comparison to other sectors of the state's economy. The total contribution of mineral and mineral fuel employees' wages to the state's economy is about \$717 million.

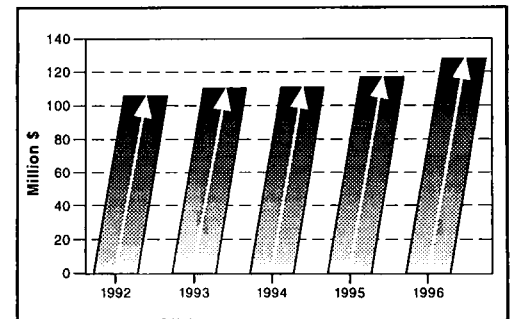


Figure 4. Property tax revenues from mineral properties.

COAL

Production

The Colorado coal industry has exhibited an overall trend of production growth through the 1970s, 1980s, and early 1990s (Fig. 5). In 1994 and 1995, Colorado coal companies produced record and near record amounts of coal and the Energy Information Administration (EIA) ranked Colorado 13th and 14th among coal producing states in those years. Production in 1996 was nearly 24.7 million tons, down from the 25.9 million tons produced in 1995. During 1996, there were only 13 mines producing coal in the state (Fig. 6) down from 14 mines in December of 1995. Most of the production was shipped to purchasers by rail.

Coal was produced from nine of Colorado's 63 counties in 1996—Delta, Fremont, Gunnison, LaPlata, Mesa, Moffat, Montrose, Rio Blanco, and Routt (Fig. 7). Coal production from the nine underground mines was two-thirds of the total, with production from surface mines making up the remaining third. The three largest mines each produced just under 6 million tons. ARCO's West Elk underground mine in Gunnison

County was the state's top producer with 5.9 million tons (Fig. 8). The next highest producer was the Cyprus Amax Foidel Creek (Twentymile) underground mine in Routt County with 5.8 million tons. Moffat County's Colowyo Mine was the third most productive mine in the state, and the most productive surface mine. The 5.7 million tons produced

by the Colowyo Mine represent more than a million ton increase over the preceding year.

Economic Impact

By the end of December, 1996, Colorado's coal mines employed 1,416 miners (Table 1) down from 1,694 at the end of 1995. The average wage of Colorado coal min-

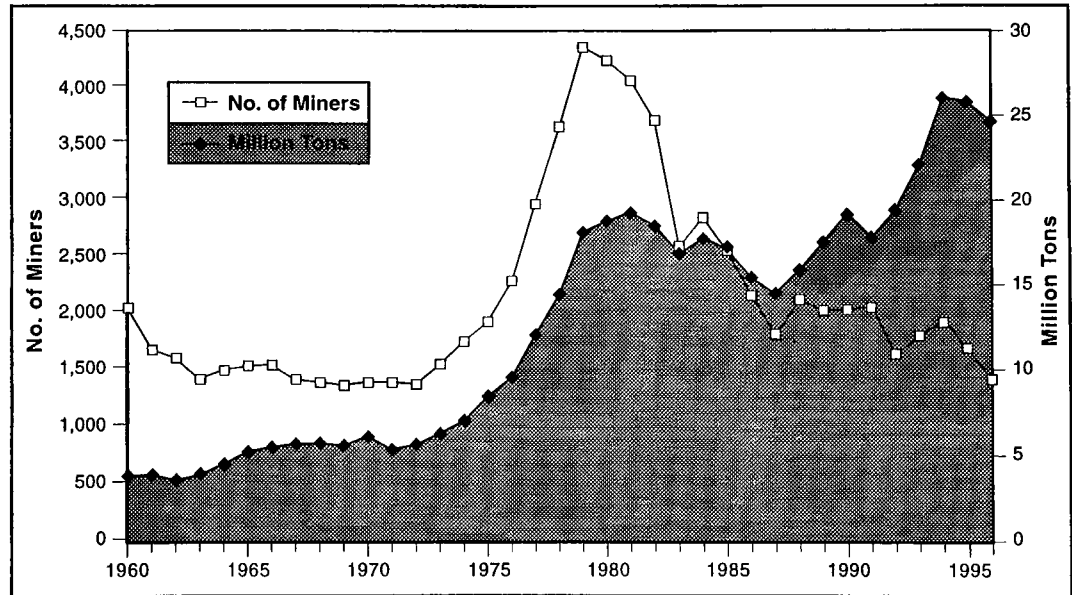


Figure 5. Coal production and employment in Colorado, 1960–1996. Source: Colorado Division of Minerals and Geology (DMG).

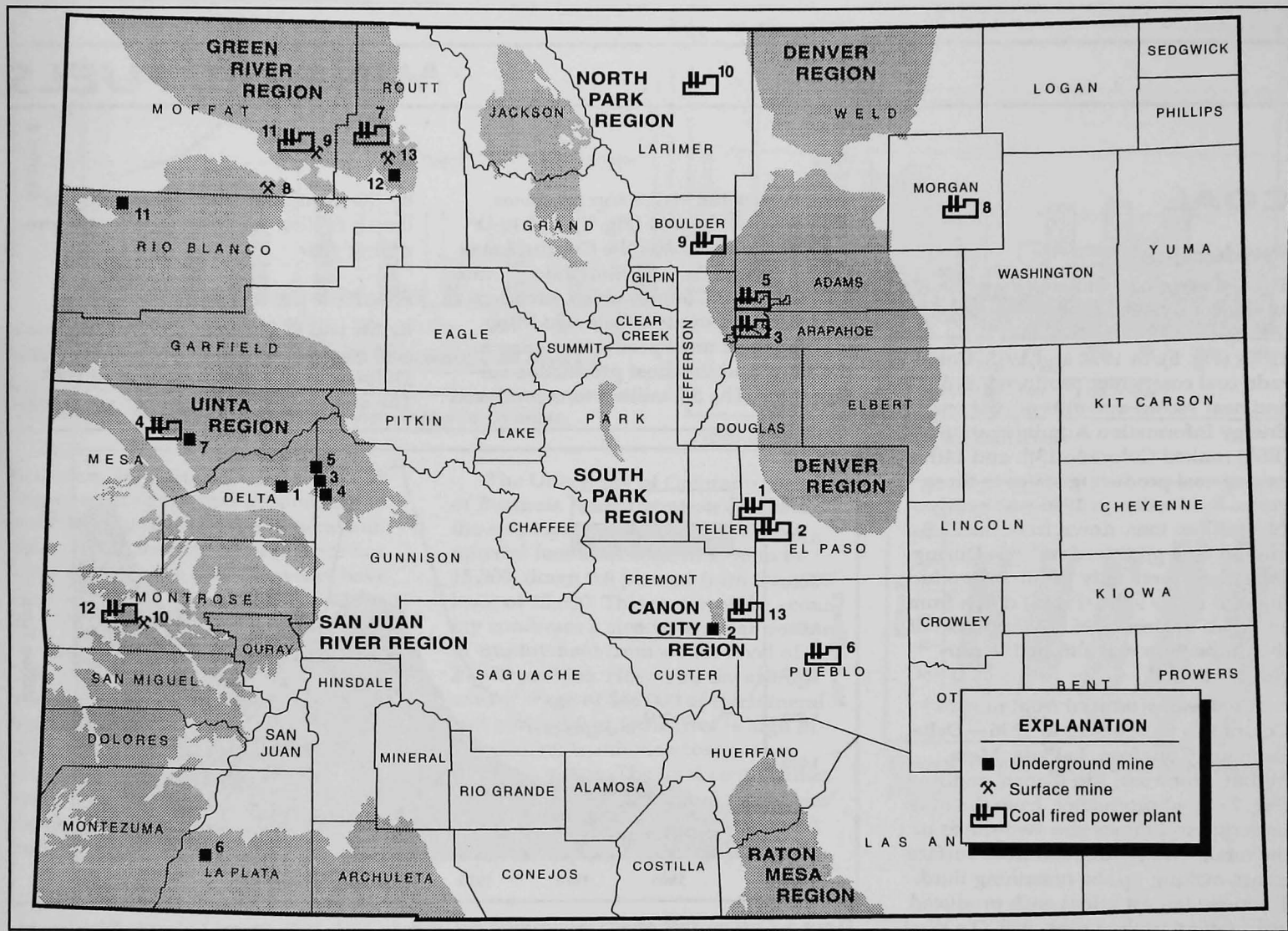


Figure 6. Coal mines and coal fired power plants in 1996. Mine numbers correspond to Table 1 and plant numbers correspond to Table 2.

Table 1. Colorado mines that produced coal in 1996. (Sources: DMG)

Mine No	County	Coal Region	Mine Name	Operator	Twp, Rge	Geologic Formation	Bed Names	Seam Thickness (ft)	BTU Avg	Mine Type	Mining Method	1996 Prod. (tons)	Dec 1996 Miners	Ship-ment Method
1	Delta	Uinta	Bowie Mine #1	Bowie Resources Ltd.	13S, 92W	Mesaverde	D	10-20	11,400	U	Continuous	605,657	67	Rail
2	Fremont	Canon City	Southfield	Energy Fuels Coal, Inc.	20S, 69W	Vermejo	Jack-O-Lantern Red Arrow	6 5.5	11,100	U	Continuous	170,387	28	Rail, truck
3	Gunnison	Uinta	Bear No. 3	Bear Coal Co., Inc.	13S, 90W	Mesaverde	B	8-10	12,200	U	Continuous	335,763	0*	Rail, truck
4	Gunnison	Uinta	West Elk	Mountain Coal Co. (ARCO)	13S, 90W	Mesaverde	B	16	11,700	U	Longwall, Continuous	5,948,912	209	Rail
5	Gunnison	Uinta	Sanborn Creek	Oxbow Carbon & Minerals, Inc. (Pacific Basin Resources)	13S, 90W	Mesaverde	B	18	12,375	U	Continuous	1,157,121	103	Rail
6	La Plata	San Juan River	King Coal	National King Coal, Inc.	35N, 11W	Menefee (Mesaverde Group)	Upper bed	5.3-6	13,100	U	Continuous	198,875	48	Truck
7	Mesa	Uinta	Roadside	Powderhorn Coal Co. (Peabody)	11S, 98W	Mesaverde	Cameo B	7-8	11,800	U	Continuous	625,885	45	Conveyor
8	Moffat	Uinta	Colowyo	Colowyo Coal Co. (Kennecott)	4N, 93W	Mesaverde	A-F, X,Y	8 beds- 5.3-12.3	10,461	S	Dragline, shovels, dozers	5,713,564	275	Rail
9	Moffat	Green River	Trapper	Trapper Mining, Inc.	6N, 90W	Mesaverde	G,H,I, Q,R	4, 6.5, 13, 4	9,900	S	Dragline, dozers, hyd. excav.	1,974,410	107	Truck
10	Montrose	San Juan River	New Horizon	Western Fuels Assn.	46N, 15W	Dakota	1 & 2	1.6-3.3, 5.9-7.9	10,300	S	Shovels, dozers	361,667	20	Truck
11	Rio Blanco	Uinta	Deserado	Western Fuels-Utah, Inc.	3N, 101W	Mesaverde	D seam	8-9	10,930	U	Longwall, continuous	530,454	128	Rail
12	Routt	Green River	Foidel Creek (Twentymile)	Twentymile Coal Co. (Cyprus Amax)	5N, 86W	Mesaverde	Wadge	9.5	11,200	U	Longwall, continuous	5,844,262	312	Rail
13	Routt	Green River	Seneca II	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	1,222,498	74	Truck, rail
Total												24,689,455	1,416	

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

* Mine closed in November, 1996

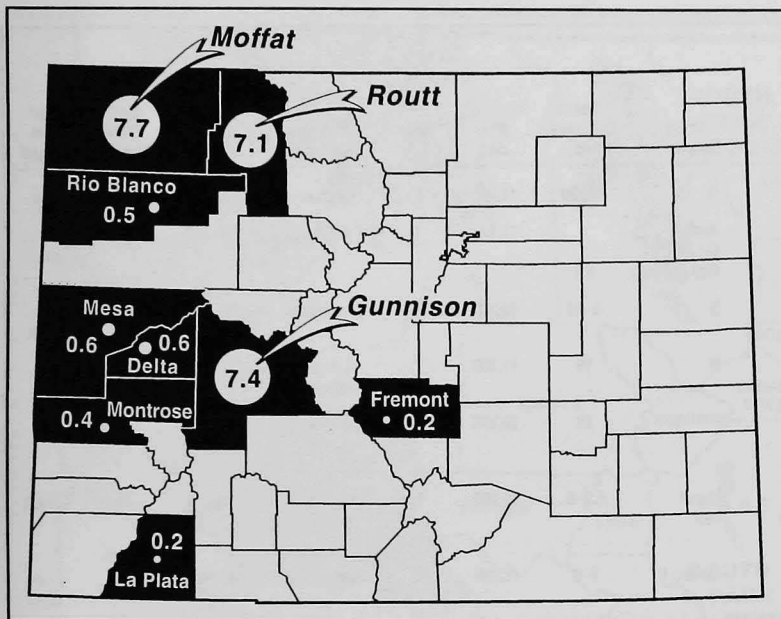


Figure 7. Colorado coal producing counties. Size of circles indicates relative amounts of coal production in each county. Source: DMG.

million. At an approximate average price of \$13 per ton, 1996 production is valued at an estimated \$321 million.

Coal Reserves and Geology

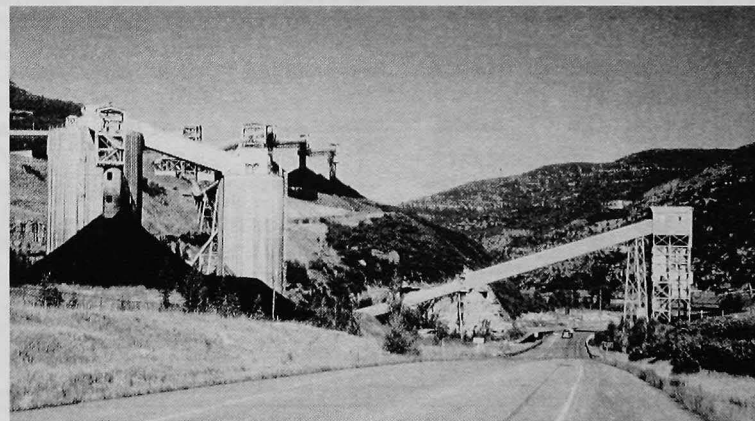
Coal underlies 29,600 square miles or 28 percent of Colorado, and the state has some of the highest quality coal in the world. Resources range in rank from lignite in the Denver Basin to anthracite near Crested Butte. However, more than 70 percent of the resource is bituminous.

Of the coal currently being mined, the average heat value is high—ranging from 9,900 to 13,100 Btu/lb. Over 70 percent of the mined coal is bituminous with the remainder subbituminous. Furthermore, all the coal being produced is low sulfur. The ash content of most mined coals is also low at 6 to 10 percent. Fig. 10 is a comparison of Colorado coal quality factors with those

ers was \$52,700—more than double the average wage in the state. Forty seven percent of the miners belonged to a union.

Coal mining occurred on a mix of federal, state, and private lands (Fig. 9). Approximately 44 percent of the mining was on federal leases, 15 percent on state leases, and 41 percent on private land. According to the Colorado Mining Association (CMA), about \$28 million came to the state from taxes, royalties and rentals during the 1994-1995 fiscal year (Fig. 9). At an approximate average price of \$14 per ton, the total 1995 production had an estimated value of \$363

Figure 8. Arco's West Elk Mine, Somerset coal field, Gunnison County, Colorado.



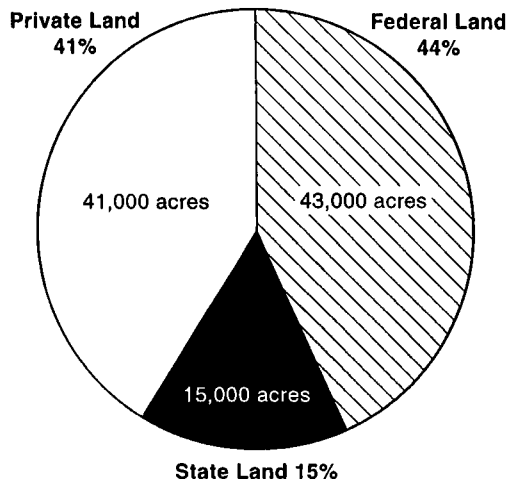
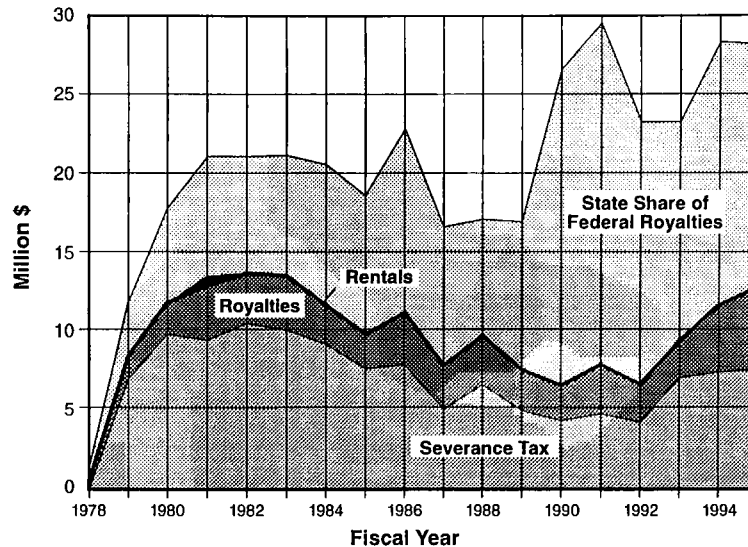


Figure 9. Coal ownership and income graphs. Sources: DMG and EIA.



of several other coal producing states. Much of the coal is clean enough to burn without any washing; however, coal preparation plants serve five of the mines in the state (Table 3). Although some Colorado coal is coking quality, the current production is almost exclusively being used as steam coal.

All the mines in 1996 produced Cretaceous age coals from either the Mesaverde, Dakota, or Vermejo formations. Eleven of the thirteen mines, accounting for over 98 percent of the production, are located in the Uinta or Green River coal regions of northwest Colorado (Fig. 6) and produced Mesaverde coal. In the state as a whole, seams mined by surface mining methods

ranged from 1.6 to 20 ft thick. Underground mined seams were anywhere from 5 to over 20 ft thick (although the actual maximum thickness recovered was 12 ft). Overburden depths to mined seams reach a maximum of 2,100 ft.

The EIA estimates Colorado's demonstrated coal reserves (see Fig. 11) at about 16.8 billion tons (as of January 1, 1995) making Colorado 8th among the states in demonstrated reserves. Furthermore, of the 16.8 billion ton total, more than 11 billion tons are low sulfur (<0.6 pounds of sulfur per million Btu).

Unfortunately, according to the EIA, about 10 percent of the underground reserves and 11 percent of the surface

reserves are inaccessible. In addition, recovery factors for the 90 percent of reserves which are accessible are about 88 percent for the surface reserves and around 50 percent for underground reserves in the state. The overall recovery factor applied to accessible coal in place was 66 percent in 1995. This gives Colorado an estimated recoverable reserve base of over 10 billion tons remaining as of January 1, 1995,—a 400+ year supply at current production rates. (For comparison, production of Colorado coal from the 1860s to the present has been under a billion tons.)

Recoverable reserves under lease at active mines were 692 million tons in 1995. At current production rates, this is

Table 2. Coal fired power plants in Colorado, 1996. (Consumption tonnage from 1997 Keystone Coal Industry Manual.)

No	Plant	Utility	Location	1995 Consumption Thou. Tons
1	Drake	Colorado Springs	Colorado Springs	699
2	Nixon		Colorado Springs	708
3	Arapahoe	PSC of Colorado	Denver	504
4	Cameo		Cameo	249
5	Cherokee		Denver	1,628
6	Comanchee		Pueblo	2,412
7	Hayden		Hayden	1,727
8	Pawnee		Brush	2,194
9	Valmont		Boulder	511
10	Rawhide	Platte River Power	Wellington	1,048
11	Craig	Tri-State G&T Assn., Inc.	Craig	4,025
12	Nucla		Nucla	374
13	Clark	Utilicorp United, Inc.	Canon City	143
Total				16,222

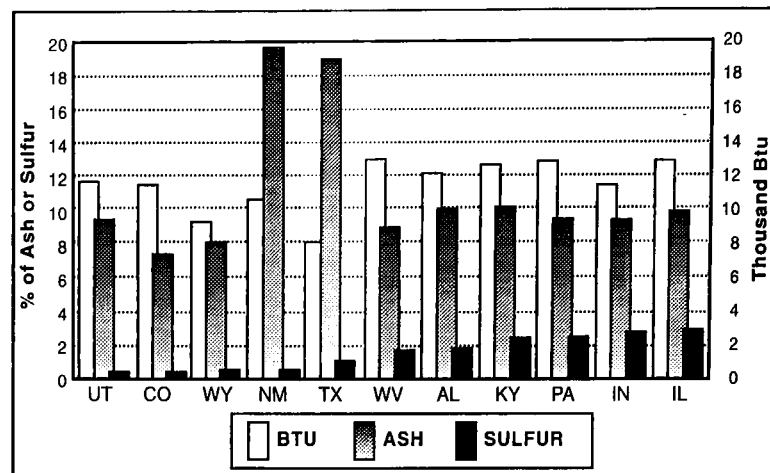


Figure 10. Quality comparison of coal produced in Colorado and selected states. Analyses from Keystone Coal Industry Manual, 1997.

a 28 year recoverable coal supply 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, and several mine expansions and new mines are being planned (see News and Developments section below). Based on planned or recent expansions and previous increases in production, the CMA predicts an increase in production to over 30 million tons within the next decade.

Consumption

In 1995, approximately half of Colorado's coal production was burned in the state and half shipped out-of-state (Fig. 12).

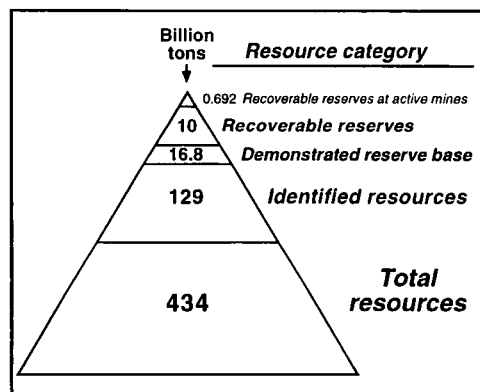


Figure 11. Colorado coal resources and reserves. Sources: USGS, CGS, and EIA.

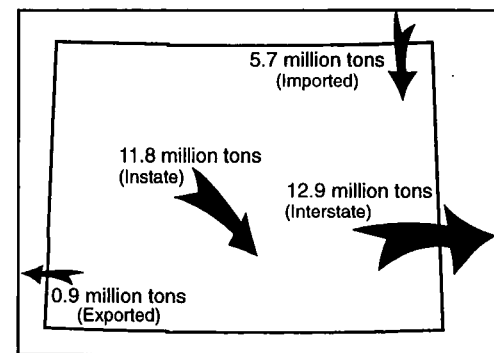


Figure 12. Colorado coal distribution diagram. Source: EIA.

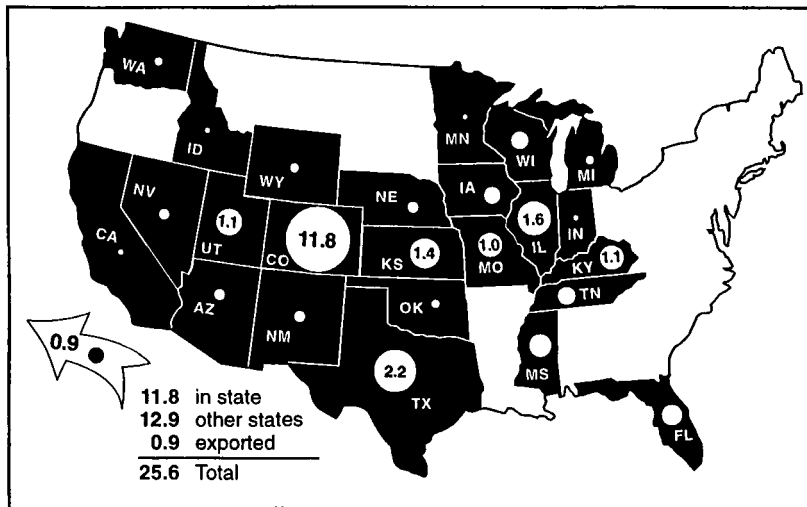


Figure 13. Distribution of Colorado coal in 1995. Source: EIA.

That year Colorado coal was shipped to 23 other states (Fig. 13). Texas, Illinois, Kansas, and Utah were the largest out of state consumers. In addition, a total of 900,000 tons was shipped to three for-

Colorado's Western Slope mines (Fig. 14) and Wyoming's Powder River Basin. In fact, 95 percent of the energy input at Colorado's electric utilities comes from coal (Fig. 15). Other coal consumers

eign countries in 1995—Taiwan, Japan, and Turkey. This was a 150,000 ton increase from the previous year.

According to the EIA, total coal consumption in the state in 1995 was about 17 million tons. A dozen Colorado power plants consumed the majority of the total, about 16.2 million tons (Table 2); this coal originated in

were comparatively minor; several industrial plants burned 729,000 tons in 1995. Residential and commercial consumption was a mere 20,000 tons.

Productivity and Capacity

The larger underground coal mines in the state have been increasing their production by the use of more efficient technology such as longwall mining (See mining method, Table 1). Colorado longwall mines broke state and world production records for the third consecutive year. Coal Age magazine reports that the Twentymile Mine established a new world record for monthly underground coal production in August 1996. That month the mine produced 893,108 tons of coal to surpass the West Elk Mine's previous world record of 781,355 tons set in April 1996. The Twentymile Mine has since installed a new longwall system to mine a panel over 3 miles long—the longest in the world.

The longwall systems operating in Colorado in the past five years had panel widths ranging from 650 to 950 ft, panel lengths from 6,000 to 17,600 ft, and cutting heights from 7 to 12 ft (Table 4). The longwall shearers (Fig. 16) cut a volume of coal equivalent to the panel width multiplied by the cutting height and a cutting depth of approximately 30 to 36 inches each time they pass over the longwall face. The cut coal falls on to a conveyor below and the entire longwall system advances to make the next pass. In this manner, a long wall can advance

Table 3. Coal preparation plants in Colorado. Source: 1997 Keystone Coal Industry Manual.

Company	Name	Location	Type	Raw Feed (tph)	Year Built
Basin Resources, Inc.	New Elk Prep Plant	Weston	Heavy-media washer, spirals, wash tables	550	1984
Cyprus Amax	Twentymile Coal Co.	Oak Creek	Heavy-media cyclones	250	1995
Energy Fuels Coal, Inc.	Southfield Mine	Canon City	Heavy-media washer and cyclones	240	1979
Powderhorn Coal Co. (Peabody)	Powderhorn Prep Plant	Palisade	Heavy-media washer and cyclones, wash tables	400	1978
Western Fues Utah, Inc.	Deserado Mine	Rangely	Heavy-media cyclones, jigs, spirals	900	1983

Table 4. Colorado longwall statistics. Source: COAL Magazine, February 1997.

Mine	Seam	Panel Width (ft)	Panel Length (ft)	Overburden (ft)	Seam Height (in.)
Empire	E	750	17,600	600-1,200	cut 120
Twentymile	Wadge	840	9,000	600-1,300	96-114 cut 102
West Elk	B	950	9,000	600-1,400	276 (cut 144)
Deserado	D	800	6,000	1,600-2,100	96-102
Golden Eagle	Maxwell	650	8,900	600	96 (cut 84)

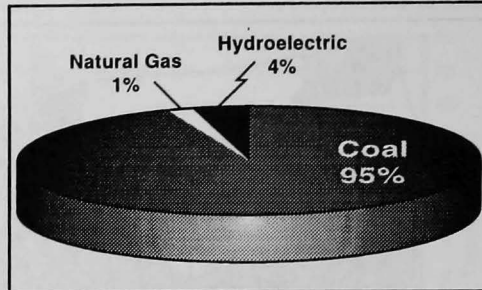


Figure 15. Energy input at Colorado electric utilities. Source: EIA.

News and Developments

Several mines closed or were partially idled during the year. The Bear family closed the Bear #3 Mine in Gunnison County on November 11, 1996. Coal Outlook later reported that the mine had been close to running out of economic reserves in the B seam, but a roof fall and other problems accelerated the closure. However, the Bear Coal Company has begun permitting a new mine, the Bowie #2, to produce a higher Btu (13,000 Btu/lb) seam in Delta County. In addition, Oxbow Carbon & Minerals has gone to a seven day-a-week schedule to increase their B seam production in the Sanborn Creek Mine to make up for the lost Bear Mine tonnage. Oxbow is also considering converting the Sanborn Creek Mine into a longwall mine.

Powderhorn Coal closed the south portal of its underground mine in Mesa County on December 6, 1996. Geologic conditions hurt the mine's ability to



Figure 14. Trapper Mine, Moffat County, with Craig Power Station in background.

as much as 50 ft a day in the direction of the panel length. The EIA stated that productivity of longwall mines in Colorado was the highest in the country during 1994 at 5.92 tons per worker-hour versus 3.84 tons per worker hour for mines using continuous mining machines (Fig. 17). Smaller underground mines in the state which use continuous

miners or conventional mining methods have a difficult time competing with the efficient longwall operations.

According to the EIA, the productive capacity of Colorado mines in 1995 was over 32.4 million tons. Given the 1995 production of 25.9 million tons, the capacity utilization of Colorado coal mines was approximately 80 percent in 1995.

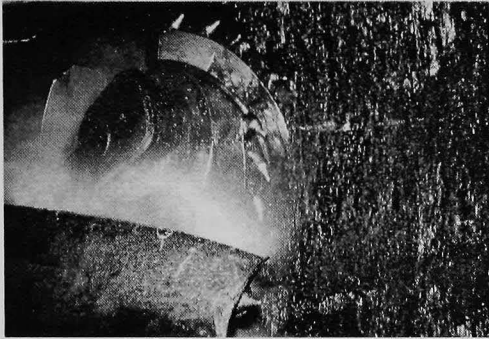


Figure 16. Longwall shearer at the West Elk Mine.

compete with larger operations in the current economic climate. The north portal will continue to operate to fulfill contract obligations to Public Service Company's Cameo power plant. However, the number of employees is projected to decrease from 124 to 45 and a 60 percent reduction in production is anticipated.

After losing \$32 million dollars of equipment, including a longwall system, to a fire in February 1996, the Western Fuels Deserado Mine resumed coal production and now has three continuous miners operating in the D seam. Coal Week reports the mine signed a new three year contract with the United Mine Workers of America and hopes to install a new longwall in late 1997.

In addition, the October Coal Age reports that Cyprus Amax signed a contract to supply 2.8 million tons of coal to the Carbon II power plant in Piedras Negras, Coahuila, Mexico. The plant is

operated by the government-owned electric utility, Comision Federal de Electricidad. The coal will travel 1,550 miles by rail through Texas and represents the utility's largest coal purchase outside of Mexico to date.

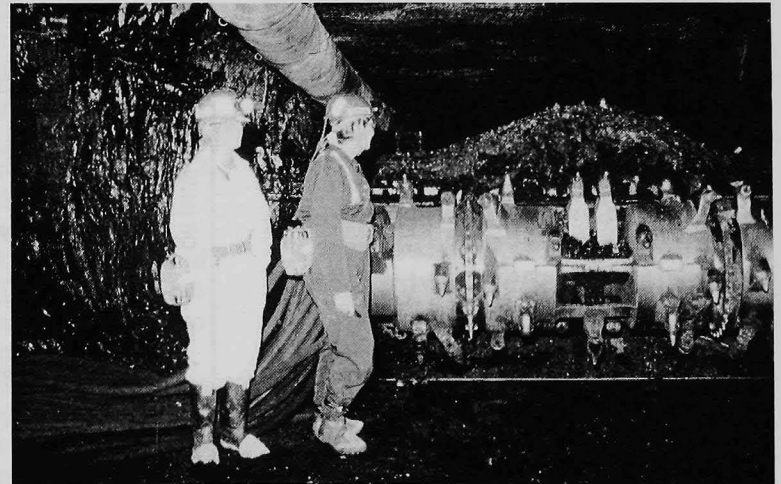
Coal Outlook reported in May that Peabody is exploring the possibility of opening a new longwall mine in Routt County to produce from 5 to 8 million tons of Federal coal per year from the Wadge seam. A mine could be operating around the year 2000 if Peabody decides to proceed with the project.

Coal Outlook also reported in May that A.P. Maxwell obtained mineral and surface rights under a 33 year lease on 18,000 acres in the Lorencito Canyon area of Las Animas County. Maxwell conducted core drilling several miles from the recently reclaimed Golden

Eagle Mine. By September, Maxwell was joined by Taiheiyu Kouhatsu, a Japanese coal producer. The property is said to contain an estimated 175 million tons of surface and deep reserves. Coal Btu is between 12,500 and 13,000 Btu/lb, sulfur is 0.6 percent, and ash is 10 percent. Mine permitting is currently in progress with an anticipated late 1997 startup. The projected annual production is 1 million tons of both metallurgical and steam coal in 1998 and over 2 million tons after 2000. Anticipated markets include the U.S. and Japan.

Seven Colorado coal mines received safety and/or reclamation awards in 1996. Four mines, the Colowyo, Trapper, Seneca II, and New Horizon mines, were recognized by the Colorado Mining Association and Colorado Division of Minerals and Geology for

Figure 17. Continuous mining machine (or continuous miner) at the West Elk Mine.



their commitment to safety. The Colowyo Mine completed 1.8 million worker hours without a lost time injury and was awarded the Sentinel of Safety award in the surface mine category by the U.S. Department of Labor's Mine Safety and Health Administration and the National Mining Association. The Seneca II, Edna, Golden Eagle, Trapper, and Sanborn Creek mines were given reclamation awards for environmental and reclamation achievements.

OIL AND GAS

Production

Colorado hydrocarbon production in 1995 totaled 28.6 million barrels of oil (MMBO) and 554.5 BCF of natural gas. Carbon dioxide production totaled 298.9 BCF. In 1995 Colorado ranked ninth of all the states in daily crude and lease condensate production with 78,142 barrels of oil per day (BOPD) and seventh in daily gas production with 1.52 BCF per day. Consumption of natural gas in the state in 1995 was 283.6 BCF. Accordingly, Colorado in 1995 consumed 51 percent of its produced gas volume.

Extrapolation of the state's 1996 January through September hydrocarbon and carbon dioxide production volumes provided by Colorado Oil and Gas Conservation Commission (COGCC) suggests full year production figures will be 25.6 MMBO, 556 BCF of natural gas, and 323 BCF of carbon

dioxide (Fig. 18). The projected 1996 oil volume of 25.6 MMBO is a 10 percent decline from 1995. This continues the long term slide in Colorado oil production that began in 1977. Projected 1996 gas volumes (natural gas & carbon dioxide), if correct, will establish new state production records.

Colorado coalbed methane production in 1995 totaled 240 BCF which placed Colorado in second place in the U.S. behind New Mexico's 574 BCF. Coalbed methane production in Colorado in 1996 is expected to total 255 BCF. This anticipated "new" record volume represents just over 46 percent of the state's total gas production, up from a 39 percent contribution in 1995 (Fig. 19).

Nationally, coalbed methane production grew by more than 12 percent in 1995. Most of the increase occurred in the San Juan Basin of Colorado and New Mexico. Coalbed methane production in 1993 represented about 3 percent of the nation's total dry gas production. By 1995, this proportion had grown to over 5 percent. Colorado's 1995 coalbed methane volume accounted for nearly 25 percent of this component of the U.S. gas supply.

In 1995, Rio Blanco County led all counties in oil production with 9,247,806 barrels of oil. The Rangely field's Weber pool (Permian and Pennsylvanian in age) produced 8,875,731 BO which provided 96 percent of the

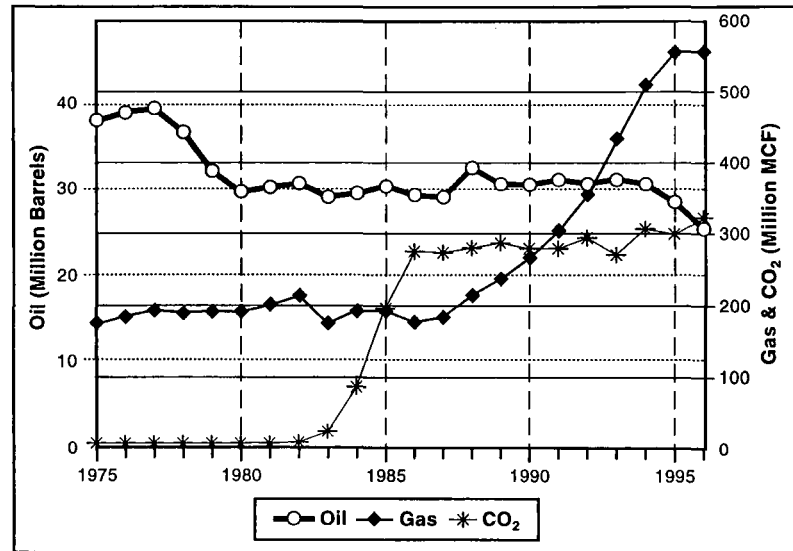


Figure 18. Colorado oil, gas, and carbon dioxide production 1975-1996. Note general rise in gas production and decline in oil production.

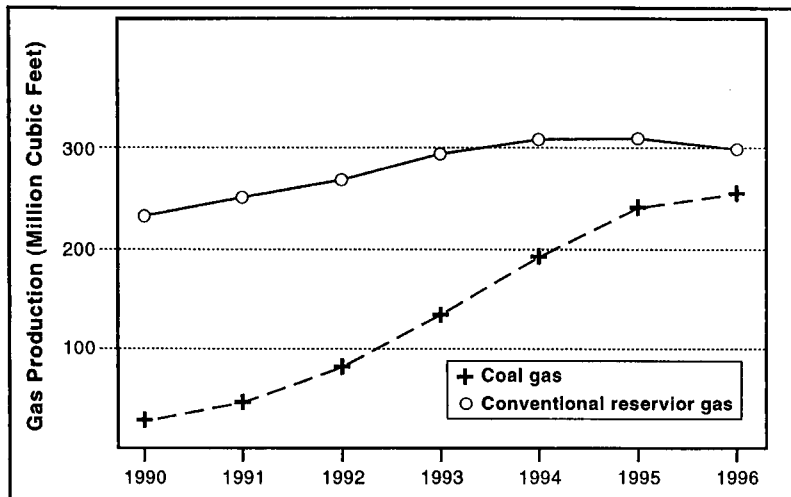


Figure 19. Annual volumes of coal gas and conventional reservoir gas in Colorado.

county total. Second and third place in county oil production went to Weld County (8,490,483 BO) and Cheyenne County (3,971,059 BO). Wattenberg field was the major contributor in Weld County (80 percent). The top three natural gas producing counties in 1995 were La Plata (266.3 BCF), Weld (128.2 BCF), and Garfield (38.0 BCF). La Plata County's Ignacio Blanco field Fruitland Formation coalbed methane reservoir (Late Cretaceous in age) contributed 234.4 BCF (88 percent) of the county natural gas total. Wattenberg field provided almost 90 percent of the Weld County natural gas total.

In 1994, the total producing well count in Colorado was 16,380. This total included 68 carbon dioxide producers,

counties in number of active wells in 1994 and 1995 with totals of 8,074 and 8,145, respectively. For both years, these Weld County totals represented about 49 percent of the state's active wells.

In 1995, 32 of Colorado's 63 counties were oil productive; 35 produced natural gas; 7 produced coalbed methane; and 3 produced carbon dioxide. Four fields account for all of Colorado's carbon dioxide production: Dike Mountain and Sheep Mountain fields in the northwestern part of the Raton Basin in Huerfano County; McCallum South field 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

928 coalbed methane producers, and 15,384 wells producing natural gas and/or oil from conventional reservoirs. The well count increased slightly in 1995 to 16,565, an increase of 185. The break down by category is: 69 carbon dioxide producers, 967 coalbed methane producers, and 15,529 conventional wells. Weld County led all

these fields accounted for 99 percent of the 1995 Colorado carbon dioxide production stream: McElmo with 219.6 BCF and Sheep Mountain with 77.9 BCF. There are 16 Colorado fields that produced coalbed methane in 1995 and 1,055 fields that produced oil and/or natural gas from conventional reservoirs.

Value and Pricing

The total value of 1995 oil, gas and carbon dioxide production in Colorado was \$1,204 million dollars: oil \$492 million, natural gas \$660 million, and carbon dioxide \$42 million. The total value in 1996 for these commodities should be approximately \$1,434 million dollars: oil \$533 million, natural gas \$856 million, and carbon dioxide \$45 million.

The basis for the 1995 values was derived by using an average wellhead price of \$15.17 for a BO, \$1.19 for a thousand cubic ft (MCF) of natural gas, and \$0.14 for a MCF of carbon dioxide.

The average wellhead price in Colorado for natural gas increased in 1996 by 29 percent to \$1.54 per MCF. The average wellhead price for oil in the state in 1996 increased by slightly under 21 percent to \$20.82 per BO (Fig. 20). The wellhead price for carbon dioxide in 1996 remained flat at \$0.14 per MCF.

Fig. 21 shows 1995 Colorado oil, gas and carbon dioxide production value by county. Thirty of Colorado's 63 counties attained over \$1 million in 1995 production value of oil and gas.

Drilling Permits

In 1996, 1,163 permits were processed by the COGCC (1,002 drilling and 127 recompletion); this compares to 1,002 drilling permits and 392 recompletion permits processed in 1995. The three counties that led in 1996 permit applications were Weld (305), Las Animas (134), and Yuma (123). Weld County also led in 1995 with 254 permits. Yuma and Las Animas counties traded places in ranking from 1995 as a result of Las Animas County coalbed methane devel-

opment from Vermejo and Raton formation coal seam reservoirs surpassing Yuma County biogenic gas development from Niobrara Formation chalk reservoirs. Daily rig counts were down slightly in 1996 to an average of 13.8 from 14.9 in 1995.

Table 5 is a final list of the Colorado oil and gas fields discovered in 1995 and a preliminary list of the 1996 state oil and gas discoveries. This data has been derived from COGCC files. Fig. 22 locates these wells in a map view.

Reserves

Proven crude oil reserves in Colorado at the end of 1995 were 252 MMBO, down from 271 MMBO at the end of 1994. Proven dry natural gas reserves at the end of 1995 were 7,256 BCF, up 503 BCF from the 1994 reserve total of 6,753 BCF (Fig. 23). The 1995 figures put Colorado in ninth place among the 50 states (excluding offshore) in crude reserves and in eighth place in dry natural gas reserves (excluding offshore).

News and Developments

Acquisition, merger, and divestiture activity in the Denver Basin was a significant development in 1996. HS Resources, in two separate transactions, bought the Denver Basin properties of Basin Exploration for \$125.5 million. The transactions cover some 850 wells producing about 5.5 thousand barrels of oil equivalent (MBOE) per day with about 30 million barrels of oil equivalent (MMBOE) of proved reserves. In a separate transaction, Snyder Oil created a new company—Patina Oil & Gas Corp—through consolidation of Wattenberg field assets owned by Snyder and Gerrity Oil and Gas Corporation. Patina now holds interests in over 3,600 Wattenberg wells. The company's production is about 20 MBOE per day. Patina's net proved reserves are estimated at 82 MMBOE, over two-thirds of which are natural gas.

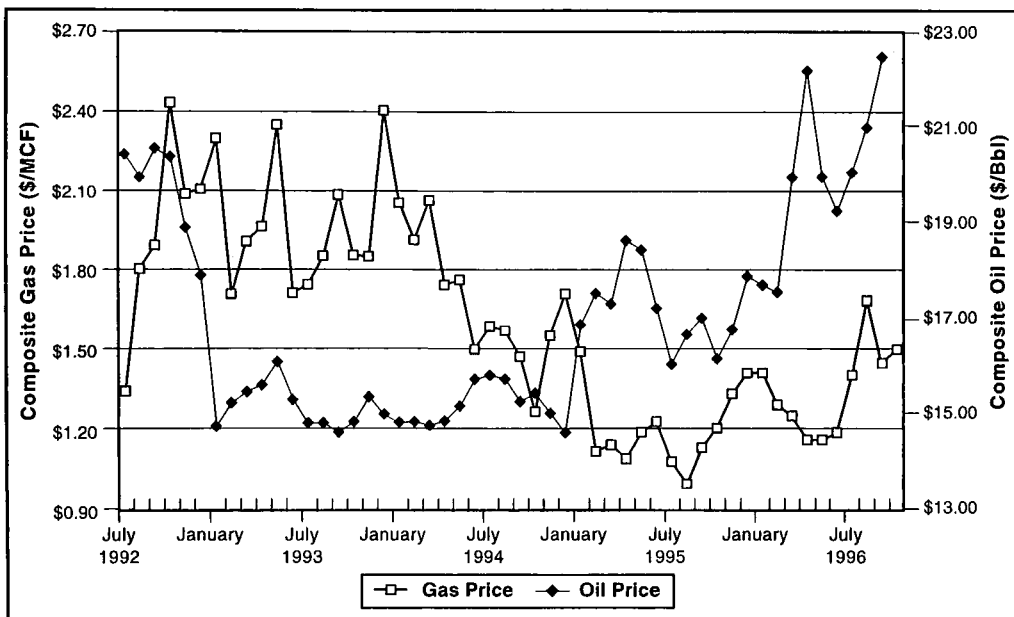


Figure 20. Colorado oil and gas price composite indices. Data from Colorado Oil and Gas Conservation Commission files.

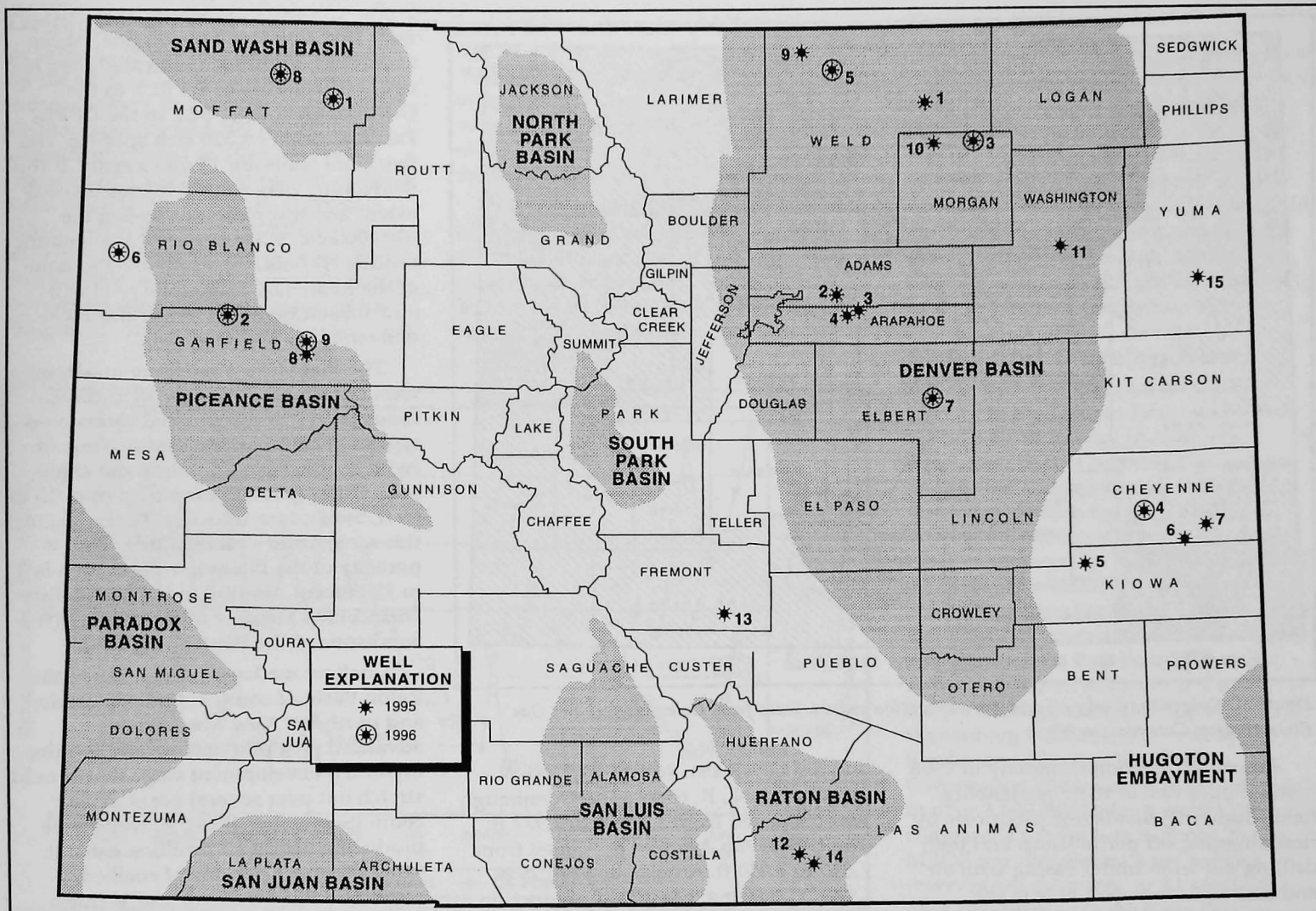


Figure 22. Location map of 1995 and 1996 wildcat oil and gas discoveries in Colorado. See Table 5 for name and date. Data from Colorado Oil and Gas Conservation Commission files.

Table 5. New oil and gas fields discovered in 1995 and preliminary discoveries for 1996. (See Fig. 22.)

Colorado Oil and Gas Fields Discovered in 1995

Map No.	Field Name	Sec	Twp	Rge	PM	County	Pay Zone	Initial Potential			
1	Abundance	19	9 N	58 W	6	Weld	Niobrara	45 BOPD	135 MCFD		
2	Bear Gulch SW	8	3 S	64 W	6	Adams	D Sand	Oil and Gas			
3	Dagger	10	4 S	63 W	6	Arapahoe	J Sand	14 BCPD	60 MCFD	50 BWPD	
4	Deep Pockets	27	4 S	63 W	6	Arapahoe	J Sand	25 BCPD	5 BWPD		
5	Elephant	32	17 S	50 W	6	Kiowa	Morrow	5,654 MCFD			
6	Hopi	34	16 S	46 W	6	Cheyenne	Morrow	42 MCFD			
7	Indian Bead	2	16 S	45 W	6	Cheyenne	Mississippian	66 BOPD			
8	Kokopelli	17	6 S	91 W	6	Garfield	Mesaverde	201 MCFD			
9	Longs Peak	24	11 N	66 W	6	Weld	J Sand	66 BOPD			
10	Prosperity	30	6 N	58 W	6	Morgan	D Sand	6 BCPD	350 MCFD	2 BWPD	
11	Rockies	12	1 N	53 W	6	Washington	D Sand	37 BOPD			
12	Saddlebag	36	32 S	67 W	6	Las Animas	Vermejo	32 MCFD		380 BWPD	
13	Skipping Stone	33	19 S	70 W	6	Fremont	Codell	12 BOPD	24 BWPD		
14	Spanish Peaks	1	33 S	66 W	6	Las Animas	Vermejo	1,148 MCFD		360 BWPD	
15	Tierra Plano	26	2 S	45 W	6	Yuma	Niobrara	195 MCFD		2 BWPD	

Colorado Oil and Gas Fields Discovered in 1996

Map No.	Field Name	Sec	Twp	Rge	PM	County	Pay Zone	Initial Potential			
1	Blue Sky	12	9 N	91 W	6	Moffat	Almond	34 BCPD	5 MCFD		
2	Bull Fork	20	4 S	97 W	6	Garfield	Mesaverde	970 MCFD		50 BWPD	
3	Fox Field	13	6 N	57 W	6	Morgan	D Sand	Oil			
4	Oyster	9	14 S	47 W	6	Cheyenne	Morrow&Keyes	1,530 MCFD			
5	Pawnee Pioneer	14	10 N	64 W	6	Weld	Richard Sand	Oil			
6	Rangely West	29	1 N	102 W	6	Rio Blanco	Castlegate	Gas			
7	Stanley Cup	36	8 S	59 W	6	Elbert	J Sand	125 BOPD	307 BWPD		
8	Teardrop	5	10 N	93 W	6	Moffat	Lewis Shale	9 BCPD	1,500 MCFD	10 BWPD	
9	Timberline	8	6 S	91 W	6	Garfield	Mesaverde	Gas			

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

by 15 mile wide "fairway" centered about 20 miles west of Trinidad, Colorado, in the headwater area of the Purgatoire River.

Active producers in the play are currently limited to three companies. Evergreen Resources Inc., of Denver, the play's most active operator (Fig. 24), has 33 wells on line producing 9.6 MMCF of gas per day. It plans to have another 10 to 15 wells on line by the end of 1996. By early 1997, Evergreen should be selling 17 MMCF of gas per day into Colorado Interstate Gas's Picketwire Lateral, the sole transportation outlet in the Raton area for coalbed methane. Evergreen has leases covering 120,000 acres in the play area which they believe could support 500 wells.

Amoco was the second largest producer with 3.1 MMCF of gas per day from 25 wells in September 1996. Amoco had planned to drill and complete five more wells by year end. Workovers, accompanied by the return of several shut in wells to production, could have brought Amoco's sales volume to 4 MMCF of gas per day in early 1997. Amoco, however, in late 1996 placed their Raton Basin holdings up for sale in order to concentrate their resources in other areas. Concurrently, they suspended further field development and as a result Amoco's production volume has fallen below 2.5 MMCF of gas per day. Amoco has at least 32,000 acres in the Purgatoire "fairway".

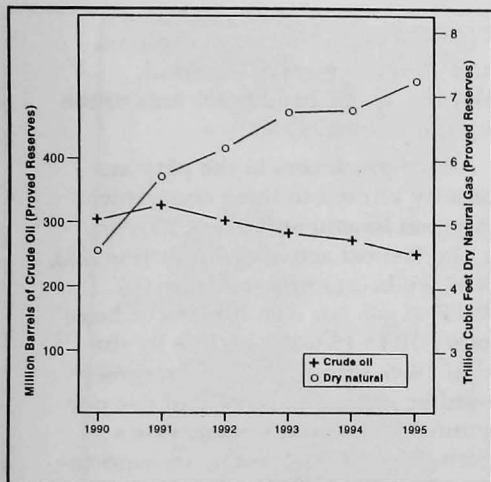


Figure 23. Colorado historical crude oil and dry natural gas reserve estimates.

Stroud Oil Properties, a Wichita, Kansas operator that recently bought Meridian Oil Corporation's Apache Canyon field, has 63,000 net acres in the fairway. Stroud operates 36 wells producing 2.5 MMCF of gas per day. Stroud will place an additional 10 to 15 wells on line during early 1997. These will be a combination of new wells and shut-in wells that have been worked over. In addition, in early 1997, Stroud began producing coalbed methane from vent holes in the underground Golden Eagle Coal Mine, which had been sealed by the mine operator, Basin Resources, in December 1995. The mine, which lies on the northern edge of the current Apache Canyon field boundary, produced coal

from the 6 to 11 ft-thick Maxwell seam in the Raton Formation. Stroud has permitted 24 vent hole locations. As of this writing, five are on line producing about 1.6 MMCF of gas per day (Fig. 25). If Stroud meets all near term development goals, they would be producing about 6 MMCF of gas per day from their Raton Basin properties by the middle of 1997. By late spring, 1997 Colorado Interstate Gas Co. could be moving 24 MMCF of coalbed methane per day out of the basin. There seems to be sufficient untapped resources in the Purgatoire area to continue building sales volumes on the Picketwire Lateral over the next few years.

Individual coal seams in the Vermejo Formation range from several inches to

over 14 ft thick, with total thickness in the Purgatoire area ranging from 10 to 44 ft. Total coal thickness in the Raton Formation in the development area averages about 50 ft, with individual seam thickness ranging from a few inches to over 11 ft. Each well is completed to produce gas from 5 to 15 individual seams. Currently the bulk of the basin's coalbed methane production is coming from the Vermejo Formation.

The depth to the base of the Vermejo Formation and the top of the conformable underlying Trinidad Sandstone in the Purgatoire "fairway" varies from 550 to 2,400 ft below the ground surface. Over half this difference is not related to subsurface structure but rather to the dissected surface

Figure 24. Pense Brothers Drilling rig setting surface casing on the Evergreen Resources, Inc. #33-32 Eureka; NE¹/₄ SE¹/₄ of sec. 32, T. 32 S., R. 65 W., Las Animas County, Colorado. The Eureka is planned as a 1,332 foot development well in the rapidly growing Spanish Peak coalbed methane field being developed by Evergreen Resources, Inc. in the central Raton Basin area.





Figure 25. Stroud Oil Properties' recent Golden Eagle Mine vent hole completion in the Apache Canyon field, Las Animas County. In March 1997, this vent hole was producing about 350 thousand cubic feet of coalbed methane gas per day into the Colorado Interstate Gas Company Picketwire Lateral. Approximate depth to the Raton Formation Maxwell coal seam, which provided this gas flow, is about 300 feet below ground surface at this location.

topography caused by downcutting of the Purgatoire River and its tributaries.

Lastly, Shell Western E&P Inc. drilled four new wells during 1996 and has planned a fifth location in their McElmo carbon dioxide field in the Paradox Basin of southwestern Colorado. It is anticipated that this activity will trigger at least a 16 percent rise in current statewide

carbon dioxide production of 680 MMCF of gas per day to 770 MMCF gas per day by late 1997.

URANIUM

Uranium prices have been going up because of increased worldwide demand and ever decreasing inventories. Shipments from the former Soviet Union

countries to the West have decreased, and several high cost uranium production plants have been shut down. Prices for uranium oxide have risen from a low of \$7 per pound in the early 90s to over \$15 per pound in early 1997. With a western world consumption in 1995 of 133 million pounds and a production rate of 66 million pounds, the picture for increasing uranium prices is good.

Cotter Corporation, a subsidiary of Commonwealth Edison, owns the Schwartzwalder Mine, the largest underground uranium mine in the United States. The Schwartzwalder mine was discovered in the mid-1940s and is located just a few miles north of Golden, Colorado (Fig. 26). In 1995 and 1996, Cotter Corporation began development and pre-production work on the mine which had been on standby for seven years. In 1997, the Schwartzwalder Mine is forecast to produce 650,000 pounds of uranium oxide.

Cotter also owns several smaller, sandstone-hosted uranium deposits on the Western Slope. It is expected that some of these mines, which produce uranium and vanadium ores, will reopen this year. Cotter is currently building a new alkaline leach recovery system for the Schwartzwalder ores in addition to the existing acid leach recovery system at its plant in Cañon City, Colorado. The mill is scheduled to reopen by early 1998.



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

METALS

Molybdenum

The price for molybdenum remained fairly stable during 1996. Cyprus Amax reported an average realization of \$5.25 per pound during the year. This contrasts sharply with the average realization of \$7.53 reported for 1995.

Production in 1996 from the Henderson Mine was 7 million tons of ore at an average grade of 0.25 percent. The molybdenum production was 31 million pounds, down 20 percent from the 39 million pounds produced in 1995. Total production for Colorado in 1995 was 42 million pounds; 3 million pounds came from the Climax Mine which operated for only four months. The estimat-

ed value of this production is \$162 million (Fig. 26 and 27).

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. 28). During 1996, gold and silver production came from three mines: the Cresson Mine in the Cripple Creek district of Teller County, the San Luis Gold Mine in Costilla County, and the Black Cloud Mine in the Leadville district of Lake County (See Fig. 26 for a location map of these mines).

The Cripple Creek and Victor Gold Mining Company, a joint venture partnership between Pikes Peak Mining Company (a subsidiary of Independence Mining) and Golden Cycle Gold Corporation, had a successful second year of operation at the Cresson Mine in the famed Cripple Creek district, Teller County. The Cresson Mine has a 1994 proven and probable reserve of 73 million tons at a grade of 0.03 ounce of gold per ton for a total of 2.2 million ounces. There is an additional 1.4 million ounces of gold within the mine area that have

Table 6. Table of major mineral producers in Colorado, numbers refer to Figure 26.

Map No.	Mine Name	Commodity	Type	Owner/Operator
1	Kelsey Lake	Diamonds	OP	Diamond Co. N.L.
2	Schwartzwalder	Uranium	UG	Cotter Corp.
3	Cresson	Gold	OP	Pikes Peak Mining Co.
4	San Luis	Gold	OP	Battle Mountain Gold Co.
5	Eagle Gypsum	Gypsum	OP	Centenx Contstruction 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	Avalanche	Alabaster, marble	UG	Crystal Valley Mining Co.
11	Grizzly Bear, Revenue	Gold and silver	UG	Sunshine Mining and Refining Co.
12	White River	Sodium bicarbonate	SOL	White River Nahcolite Co.
13	Yule Quarry	Marble	UG	Colorado Yule Marble Co.

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

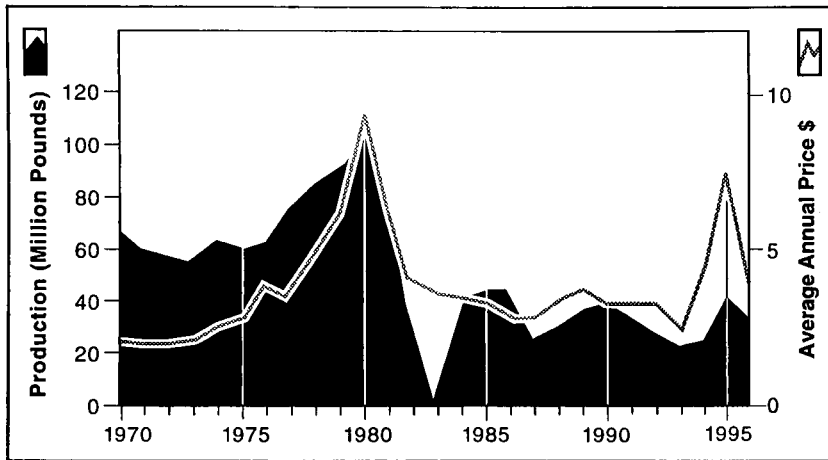


Figure 27.
Colorado
molybdenum
production

from approximately 9.5 million tons of ore. Projected production for 1997 is 198,000 ounces of gold. The deposit has an overall strip ratio of 1.7:1 and a leach pad recovery of 71 percent. Operating (cash) costs projected over the life of the mine are about \$220 per ounce of gold.

The Cripple Creek and Victor Gold Mining Company conducts an aggressive exploration program in the district. In 1995, 71,000 ft of reverse circulation and core drilling were completed. In 1996, 334,000 ft of reverse circulation and core drilling were completed and the results of this drilling indicate a continued expansion of the district wide reserves (Fig. 29 and 30).

The San Luis Gold Mine, Costilla County, had a successful year of operation

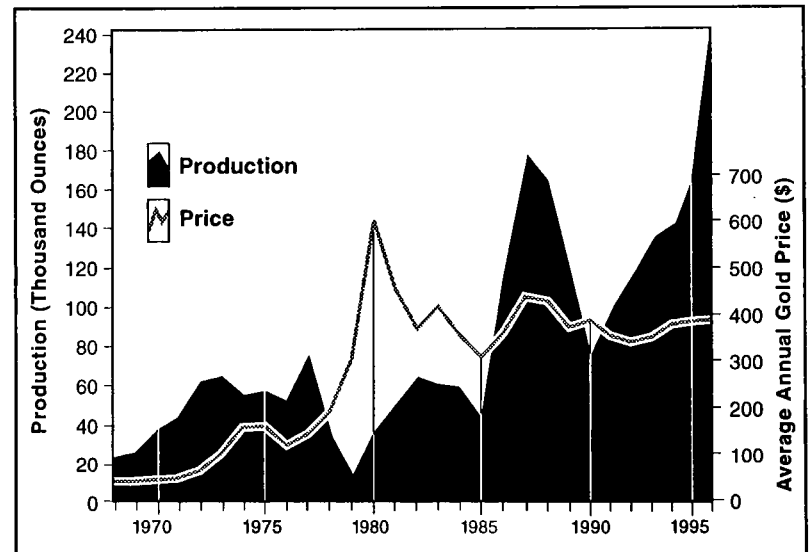
been classified as a resource. District wide reserves total approximately 97 million tons at 0.027 ounces of gold per ton.

The Cripple Creek mining district is located within a Tertiary age (32 million years) alkaline volcanic complex which was intruded into Precambrian granites and metamorphic rocks. Gold was discovered in the district in 1891 by Bob Womack. By the early 1900s, Cripple Creek was a boom town with a population of over 60,000 people. Most of the underground mines in the district were producing high grade ores of one to 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.

Production at the Cresson Mine began in February 1995, and during the

mine's first year of operation it produced 76,589 ounces of gold. In 1996, 174,000 ounces of gold were produced

Figure 28.
Colorado gold
production.



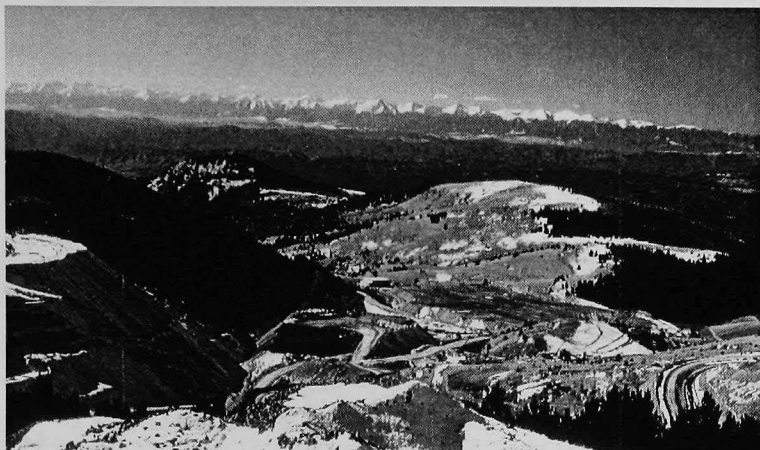


Figure 29. Overview of the Cresson Mine, Cripple Creek district from the American Eagle Mine looking west-southwest. Sangre de Cristo Mountains in background.

tion in 1996 producing approximately 68,000 ounces of gold. Unfortunately, the mine was closed because of ore exhaustion in the last quarter of 1996. The mine contained about 12,149,000 tons of ore at 0.04 ounce of gold per ton prior to the commencement of mining in 1991. About 100 jobs will be lost in an area of chronic underemployment, the San Luis Valley.

Gold is also produced as a by-product of base metal mining at the Black Cloud Mine in the Leadville district. In 1996, the Black Cloud Mine produced an estimated 6,700 ounces of gold and 210,000 ounces of silver.

Sunshine Mining Company conducted geological mapping, sampling, and core drilling on and near the Revenue-

Virginus Mine not far from Ouray, Colorado during 1995. In 1996, the company completed a resource evaluation and began the permitting process. A production decision is still under consideration. The Revenue-Virginus produced over 14.5 million ounces of silver between 1876 and 1913.

Franklin Consolidated Mining Co. acquired the Gold Hill Mill from Colino Oro Molino for a con-

sideration of \$2.5 million. The new mill is located in Boulder County and is fully permitted.

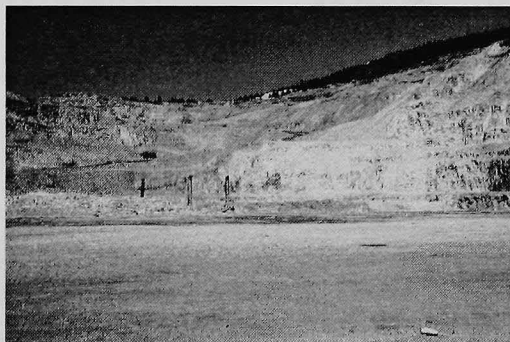


Figure 30. Floor of the Cresson Mine open pit. Drill rigs in background.

Leadville Mining and Milling Co. continued some rehabilitation and development work on their Hopemore and Hunter Mines in the Leadville district, Lake County. Also, work on the 150 ton per day mill continued. The company states that early turn-of-the-century mining only exploited the Leadville Limestone. They report that gold mineralization at grades of about one ounce per ton along with minor base metal values have been found in the Dyer Dolomite and Manitou Formation, both of which are found below the Leadville Limestone.

Base Metals

Asarco's Black Cloud Mine near Leadville is the state's sole significant base metal producer. The mine has a capacity of 900 tons per day and operates from two underground shafts. Average annual production is 8,000 tons of lead concentrate, 30,000 tons of zinc concentrate, 10,000 ounces of gold, and 320,000 ounces of silver.

In August 1996, a failure of the primary ball mill necessitated a lay-off of 78 persons. Stagnant prices forced Asarco to look closely at the mine's economics, and in November the company announced that it would lay off an additional 120 people and place the mine in a care and maintenance status. In mid-December, the company changed its plans and announced that it would repair the ball mill and reopen the mine. The full staff was recalled in February,

and the mine and mill should be back in full production by mid-March.

The orebody is a complex massive sulfide replacement deposit in the Mississippian Leadville Limestone. The ore grade is 3 percent lead, 8.5 percent zinc, 2 ounces per ton silver, and 0.06 ounces per ton gold.

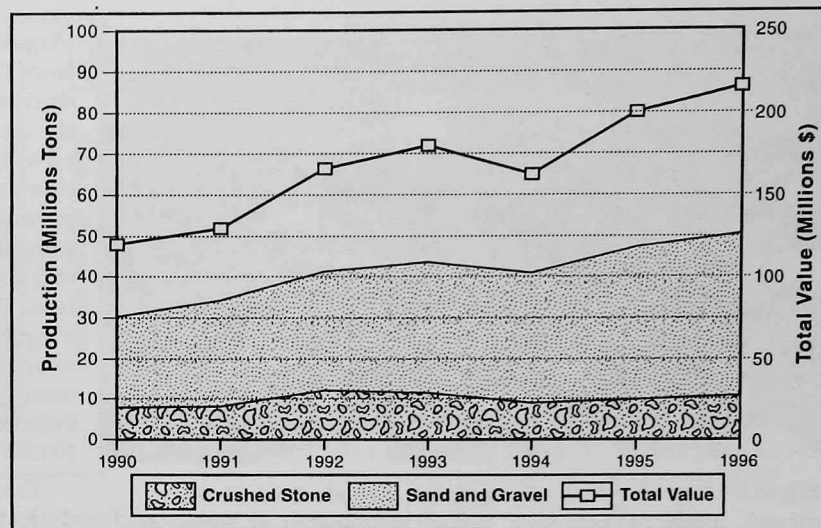
CONSTRUCTION MATERIALS AND INDUSTRIAL MINERALS

Sand, Gravel, and Aggregate

The sand, gravel, and aggregate industry produced approximately 51 million tons of material in 1996, up 7 percent from the high of 47 million tons in 1995 (Fig. 31). The value of the 1996 production is estimated to be \$228 million. Continued residential building in Colorado, especially in the Front Range counties, is partially responsible for the growth in the construction material production.

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.

Figure 31. Colorado crushed stone, sand and gravel production.



Colorado Lien Co. operates two quarries near La Porte, Larimer County. The company produces sandstone and limestone from the Pennsylvanian-Permian age Ingleside Formation at its Owl Canyon Quarry. The sandstone is used for rip rap, aggregate, and decorative stone. The limestone beds are 15 to 20 ft thick and have an average CaCO_3 content of 96 percent. Limestone is used for fillers, poultry feed, and sugar beet refining. The combined annual production from this quarry is about 300,000 tons (Fig. 32). The company also produces about 60,000 tons a year of gypsum from the Permian age Lykins Formation at its Munroe Quarry (Fig. 33). In this area, there are several small occurrences of alabaster that are quarried for specialty purposes.

Other construction and industrial minerals produced in the state during 1996 include peat, bentonite clay, common clay, and kaolin (Fig. 34).



Figure 32. Exposure of Ingleside Formation in Owl Canyon Quarry, Larimer County. Gray limestone bed exposed along the top of reddish brown sandstone.

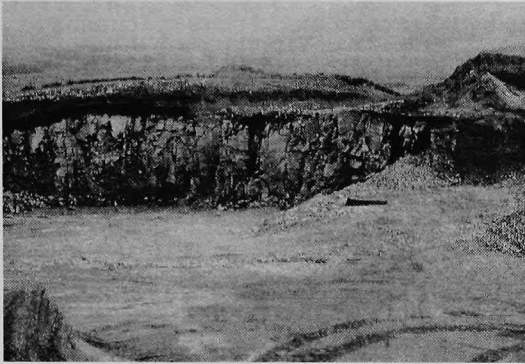


Figure 33. Exposure of gypsum beds in the Lykins Formation, Munroe Quarry, Larimer County.

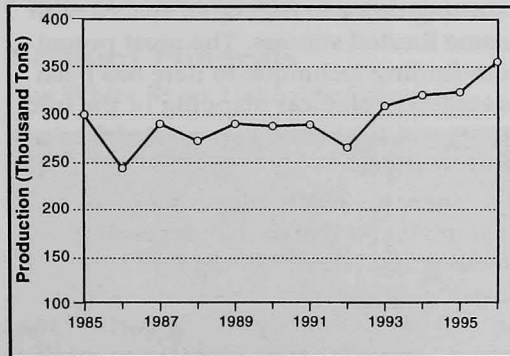


Figure 34. Clay production in Colorado.

Dimension Stone

The Colorado Yule Marble Company is mining white marble from the historic Yule Marble Quarry near Marble, Colorado. In 1996 the company produced 5,000 tons of salable marble primarily as

15 to 20 ton blocks. Production increased 13 percent in 1996 from the 1995 value of 4,400 tons. Approximately 20 percent of the production was sent overseas, primarily to Italy, Japan, and Indonesia, where it is fabricated into consumer products. The demand for stone floor tiles within the United States is increasing as the price disparity between ceramic and stone tiles diminishes. The company has no new development plans for 1997 (Fig. 35).

The Crystal Valley Mining Company conducted limited development work on their alabaster and black marble deposit in Pitkin County. The deposit is hosted by the Pennsylvanian age Belden Formation. The black marble is noted for its hardness and multicolored veinlets. The underground mine is currently at the 100 ft level; in 1997 the mine will be deepened to the 280 ft level.

In 1996, the company produced 80 tons of alabaster, about half of which was sold to New York City for use in art projects. The mine is close to receiving all the necessary operating

permits and is scheduled to commence full scale mining operations in May 1997. The planned production rate of alabaster is about 20 to 30 tons a day. When the planned development work reaches the black marble deposit at the 280 ft level the production rate should double.

Gem and Specimen Minerals

Colorado Diamond Co., a subsidiary of Redaurum Red Lakes Mines Ltd. of Toronto, began production in May 1996 at the Kelsey Lake Mine in the State Line district of Larimer County. This is North America's first and only large-scale, commercial diamond mine. Open pit

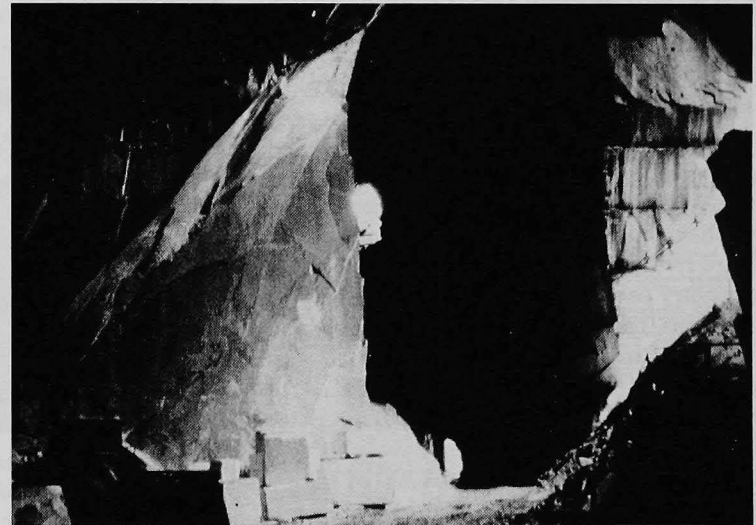


Figure 35. Blocks of Yule Marble near front end loader. Yule Marble Quarry, near Marble, Gunnison County.

mining at Kelsey Lake began in late 1995; however, the \$2 million processing plant was not completed until May 1996. The mine and plant are currently processing about 44,000 to 55,000 tons of ore per month. The kimberlite ore is soft due to weathering and no drilling or blasting is required. The plant has no primary crusher, only an autogenous mill that pulverizes the ore before it goes to four rotary pans, each 14 ft in diameter, that concentrate the diamonds. The diamond-bearing concentrate and water are passed over a vibrating grease table. The diamonds are hydrophobic and stick to the grease as the other minerals in the concentrate pass over the table to the tailings pile. The diamonds and grease are separated to recover the diamonds. The diamonds produced at the Kelsey Lake Mine are marketed as Colorado™ Diamonds and Kelsey Lake™ Diamonds.

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 (Fig. 36). 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 at Kelsey Lake and the State

Line district. The Kelsey Lake prospect consists of eight kimberlite pipes; however, the current mining program is focussed on the two largest pipes. These two pipes have a surface area of about 20 acres and contain 19 million tons of ore down to a depth of 330 ft. Initial diamond recoveries for 1996 are estimated to be 25,000 carats. The company hopes to increase production to 100,000 carats in 1997.

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



Figure 36. Raw 28.3 carat yellow diamond recovered from the Kelsey Lake Mine, Larimer County. Approximate size is 10mm by 14mm. Photo courtesy of Howard Coopersmith, Diamond Co. N.L.

the past six 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 range of hundreds of thousand dollars.

The rhodochrosite crystals occur in open spaces created by intersecting fractures. Sweet Home Rhodo Inc., the mine operator, has used sophisticated and detailed geochemical sampling including microprobe and fluid inclusion studies to understand the geochemical signature of the rhodochrosite-bearing rocks. Also, they have used ground penetrating radar to find open spaces with some limited success. The most potent ore-finding technique to date has been detailed geological mapping of the fractures and tunneling to projected fracture intersections.

There are six employees located at the mine and five at the preparation facility in Golden. Mining for rhodochrosite crystals is done slowly and carefully, and operating costs of the mine are high, about \$3,000 per day. The high unit value of the specimens is the main factor in the mine's continued operation. Most of the specimens have been sold to museums and private collectors.

Gypsum

The Eagle Gypsum Mine, Eagle County operated at its nameplate capacity of

425,000 tons, slightly higher than the 1995 production. The company continued mine development and enlargement in 1996. The gypsum ore is mined from an open pit mine using pavement profiler machines that cut a trench 12 ft wide by 0.5 ft deep (Fig. 37). The gypsum is manufactured into wallboard and other products at the plant in 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 February 1997, the company was sold to Centex Construction Products of Dallas and changed its name to Centex Eagle Gypsum Co., LLC.

Sodium Minerals

The White River Nahcolite Company

produced approximately 60 percent of the plant's nameplate capacity of 125,000 tons a year of nahcolite, NaHCO_3 , 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 ft thick "Boies Bed", a Tertiary age lacustrine deposit at a depth of 2,000 ft. Current production is from solution cavity number four which has a projected yield of 125,000 tons at a well spacing of 3,000 ft. The plant has a staff of twenty persons.

The White River Nahcolite Company is currently in the engineering phase of a planned doubling of the plant's capacity. Gradual acceptance of the company's food grade sodium bicarbonate during the past two years has caused the com-

pany to anticipate increased demand for their products.

METAL EXPLORATION ACTIVITIES

Hendricks Minerals Canada Ltd. returned the Cross and Caribou Mine properties, Boulder County, to Tom Hendricks after Echo Bay dropped the property in 1995. The Cross Mine is thought to be a stockwork vein gold deposit associated with the contact of a Tertiary age quartz monzonite and surrounding Precambrian rocks. Preliminary reserve calculations by Hendricks Minerals indicate 1.6 million tons at a grade of 0.14 ounce of gold per ton including a high grade zone of 387,000 tons at a grade of 0.21 ounce of gold per ton. Both mines were closed during 1996 because of a dispute on water quality issues with the Colorado Department of Public Health and Environment.

Sunshine Mining and Refining Co. of Idaho has entered into a joint venture agreement to explore and develop the Grizzly Bear prospect, Ouray County. The Grizzly Bear Mine produced high grade silver ore and gold ore. In 1996, the company completed a Phase 1 exploration program which consisted of revamping the underground ventilation system in a 7,600 ft tunnel built in 1978 in order to develop the old workings from a more accessible location. The

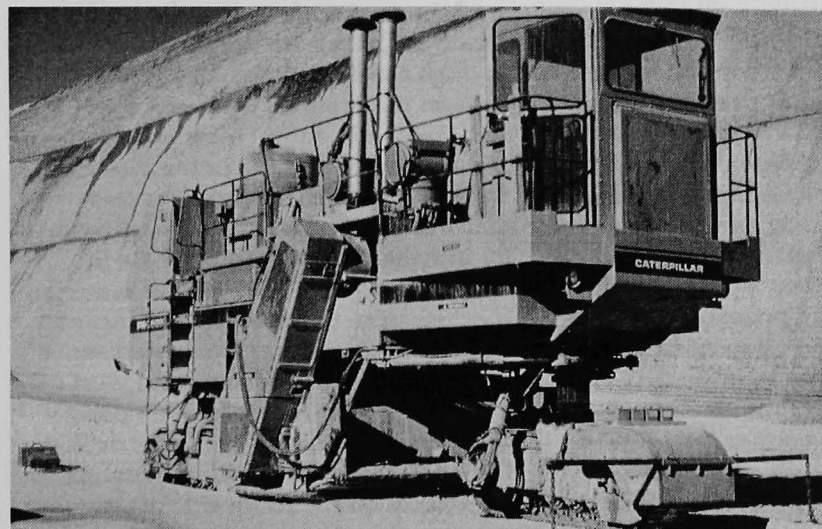


Figure 37. Front of pavement profiler. Note furrows of broken ore at the rear of the machine. Eagle Gypsum Mine, north of Gypsum, Eagle County.

company also completed 12 underground core drill holes and had encouraging results. The Grizzly Bear vein system is braided and can be up to 40 ft wide with good ore grades. It has a unique mineralogy for a San Juan Mountain vein system containing gold tellurides, bismuth tellurides, and sulfosalts. This spring a resource estimate will be completed and a decision on whether to go to a Phase 2 exploration program will be made.

Anvil Resources Ltd. has acquired kimberlite prospects in the Chicken Park area of the State Line district. Earlier prospecting in this area yielded 306 diamonds from a 325 ton sample including a 2.5 carat industrial grade diamond. The estimated grade of the Chicken Park kimberlites is 6.7 carats per 100 metric tonnes. The company drilled 12 exploration holes on the property in 1996. Eleven of the drill holes encountered kimberlite. A large bulk sample is scheduled for this fall.

Royal Gold Inc. of Denver, through its agreement with Union Pacific Resources, focussed its 1996 exploration activities on Union Pacific lands in the State Line diamond district. In 1995, the company conducted stream sediment sampling. Ten of fifty stream sediment samples yielded positive results for kimberlite minerals. At least five anomalous drainage basins without known kimberlite rocks were defined by the sampling. Activities in 1996 included geological mapping, geochemical sam-

pling, and geophysical surveys on targets developed from the 1995 exploration program. Royal Gold plans to complete follow-up exploration on several targets during 1997.

Summo Corporation, a partnership consisting of Denver-based St. Mary Minerals Inc., MLP Associates, and other investors, acquired the Copper Spur prospect in southern Routt County in September 1996. Copper mineralization at this prospect is in the upper part of the Cambrian age Sawatch Sandstone. The prospect was mined around the turn of the century and in the 1950s. Historically, the grades were 2 to 4 percent copper with small amounts of lead. Summo reopened the old workings, conducted channel sampling, and obtained an average grade of 1.75 percent copper. Plans for 1997 include further sampling and drilling on this prospect.

Summo completed a column leach test of the copper ore from their Cashin prospect, Montrose County. The results of the test indicate a 90 percent recovery in 45 days. The tabular-shaped orebody is hosted by the Triassic age Wingate Sandstone and is about 150 ft thick. The orebody consists of two layers: an upper oxide zone consisting primarily of malachite and azurite; and a lower chalcocite (sulfide) zone. The preliminary drill-indicated reserve is 13 million tons at a grade of 0.5 percent copper for a total of approximately 130 million pounds of copper. Summo continued attempts to

resolve a wilderness study area boundary dispute with the U.S. Bureau of Land Management. No new geological work was done on the property.

The Powderhorn district in Gunnison County is estimated to contain approximately 500 million tons of titanium ore. Most of the titanium resource is in perovskite, a mineral that presents unique processing problems. Teck Resources has been conducting an evaluation program called the White Earth Project on the titanium resource since 1990. In 1996, Teck started the second phase of pilot metallurgical tests which consist of converting the perovskite concentrate to titanium dioxide pigment for the paint and chemical industry. The pilot plant is expected to provide enough material for test marketing purposes.

American Soda Company, formerly American Alkali Inc., of Glenwood Springs conducted core drilling for sodium minerals on their proposed soda ash and sodium bicarbonate plant and solution mine site in the Piceance Basin, Rio Blanco County. The company plans to develop a vertical solution cavity in nahcolite-bearing oil shale in order to recover 35,000 tons of material for their pilot plant. AmerAlia Inc. of Colorado Springs has completed some core drilling on a sodium lease west of the White River Nahcolite Company solution mine. Also, U.S. Borax drilled three core holes for sodium minerals on a property on the south side of the mine.

BHP Minerals completed one exploration drill hole on its Big Creek prospect in northern Jackson County. The Big Creek prospect is a Broken Hill-type, massive sulphide target in a high grade metamorphic terrain. The company

also continued geological mapping and sampling on its Sedalia Mine and Maysville prospects in Chaffee County. The Sedalia Mine operated from 1888 to 1918 and produced about 78,000 tons of copper ore.

Phelps Dodge is actively looking at precious and base metal opportunities in Colorado. They plan a continued exploration effort in 1997.