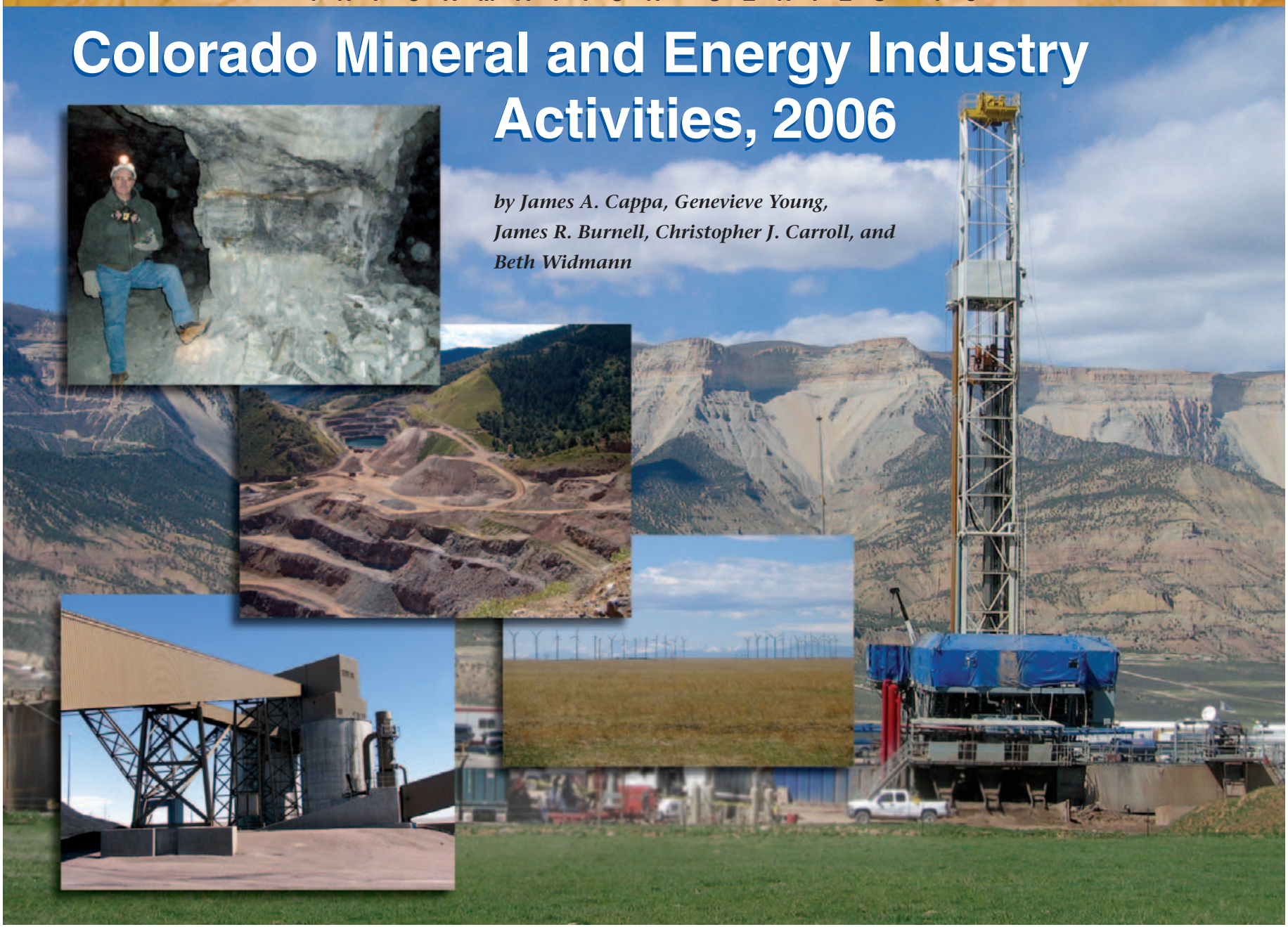
INFORMATION SERIES 75

Colorado Mineral and Energy Industry Activities, 2006

by James A. Cappa, Genevieve Young, James R. Burnell, Christopher J. Carroll, and Beth Widmann



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Cover figure captions

1. Jim Burnell (CGS) standing next to a pillar of uranium ore (grayish-black colored material) at the Sunday Mine, Montrose County.
2. Morrison Quarry, south of Morrison, Jefferson County, (photo courtesy of Aggregate Industries).
3. Ponnequin 1 Wind Farm, Weld County.
4. Rawhide Power Plant coal conveyor, Larimer County.
5. Background—Williams Company drilling for natural gas in the southern Piceance Basin, Garfield County, using Helmerich and Payne's new FlexRig 4 technology. The FlexRig 4 can drill up to 22 wells from a single site (photo courtesy of Vince Matthews, CGS).

CONTENTS

EXECUTIVE SUMMARY

The Colorado mineral and energy industries enjoyed another year of growth; not only did production increase for most commodities, but prices for most mineral and petroleum commodities, with the stark exception of natural gas and molybdenum, also increased. Employment levels increased sharply.

The Colorado Geological Survey (CGS) estimates the total value of 2006 mineral and energy production in Colorado to be **$11.609 billion**—a 5 percent decrease from the revised* 2005 total value of $12.174 billion (fig. 1, fig. 2, and table 1).

Energy, carbon dioxide, and mineral production values for 2006 are estimated at:

- **Natural gas—$7,181 million**
- **Oil—$1,401 million**
- **Carbon dioxide—$291 million**
- **Coal—$974 million**
- **Nonfuel minerals—$1,762 million**
- **Uranium—$0**

The total estimated value of oil, natural gas, and carbon dioxide production in 2006 is $8.873 billion, which is down seven percent from the 2005 value of $9.572 billion. Colorado natural gas and oil production climbed slightly during 2006; however, the average annual price for natural gas declined to $6.14/ thousand cubic feet (Mcf) from a 2005 high of $7.39/Mcf. Average annual oil prices increased to $60.32/ barrel in 2006 from $53.93 in 2005. The production and price for carbon dioxide climbed during the year, increasing the value of production from $241 million in 2005 to $291 million in 2006—a 21 percent increase. Oil, gas, and carbon dioxide average prices are obtained from the Colorado Oil and Gas Conservation Commission.

Coal production decreased from the 2005 level of 37.82 million tons to 35.49 million tons in 2006, primarily due to production shortfalls at two coal mines. The average coal price on federal leases for 2006 ranged from $25.60 to $27.44 per short ton, up 21 percent from $21.50 per ton reported in 2005. The average coal price is obtained from the federal Minerals Management Service; this price reflects contract sales of coal from federal leases. Spot prices for coal in Colorado for 2006 averaged about $36 per ton, an increase of 8.3 percent from the $33 average spot price for 2005, according to the U.S. Department of Energy's Energy Information Administration. CGS estimates the average price for all coal produced in Colorado to be $27.44 per ton. The value of the 2006 Colorado coal production is estimated at $974 million—up 20 percent from the revised* 2005 value of $813 million.

The CGS estimates the value of the 2006 nonfuel mineral production to be $1,762 million—a two percent decline from the revised 2005 value of $1,789 million. Though molybdenum production increased, the average annual price declined from the record 2005 value of $31.73 per pound to $26.50 per pound. Gold production in the state declined slightly but the average annual price increased dramatically.

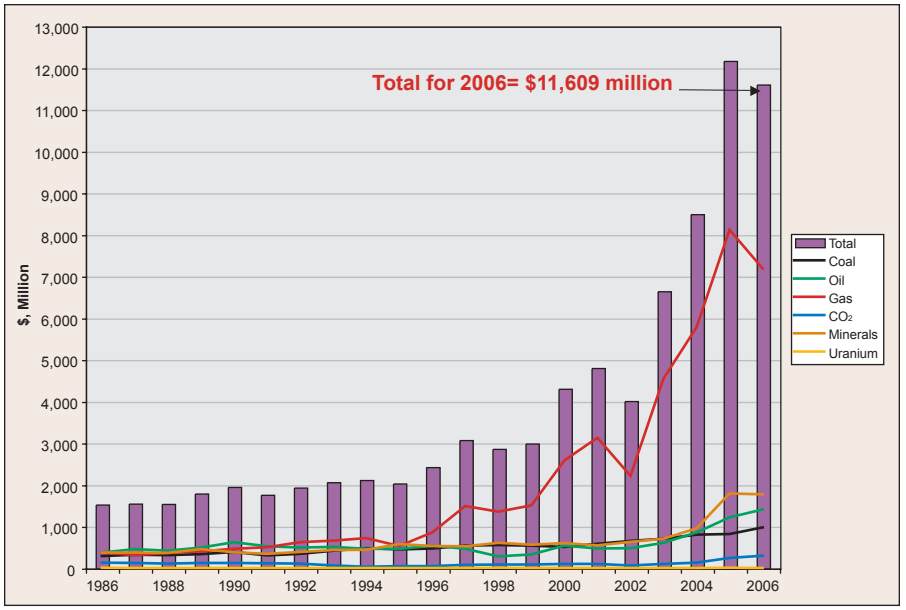

Figure 1. Colorado mineral and energy production value, 1986–2006.

Uranium and vanadium production value declined to zero in 2006 due to the closure of Cotter Corporation's four uranium mines in the Uravan district in November 2005.

Taxes and royalties from mineral and energy production flow directly back to the State of Colorado and local governments. The combined total of federal mineral lease revenues, state severance taxes, Colorado State Land Board mineral royalties and rentals, and county property taxes on mineral properties for 2006 is $663 million—up 25 percent from the $530 million collected in 2005.

* Estimated production and values are obtained from other state agencies, federal agencies, company annual reports, press releases, mine operators, and other sources. Sources of data are explained in the appropriate section in the following chapters. The 2005 production value is revised to $12,174 million from the original estimated value of $11,872 million (Colorado Geological Survey Information Series 73, *Colorado Mineral and Energy Industry Activities, 2005*).

Table 1. Colorado mineral and energy production and value, 2005 and 2006. Rounding errors are especially significant for oil and gas. Average price is annual average published price. Realized value is the amount received by companies, which is generally not equal to the average price times volume produced. Red percentage change numbers in parentheses are negative.

2006 (Estimated)	Volume Produced	Volume Sold	Average Price	Realized Value (Millions)	% Change in value from 2005
Hydrocarbon and Carbon Dioxide Production Statistics[1]					
Natural gas	1,209 Bcf	1,169 Bcf	$6.14 /Mcf	$7,181	(11%)
Crude oil	23.45 MMbo	23.22 MMbo	$60.32 /bbl	$1,401	15%
Carbon dioxide	373 Bcf	373 Bcf	$0.78 /Mcf	$291	21%
Estimated Total Value of Hydrocarbons and Carbon Dioxide				**$8,873**	(7%)
Coal Production Statistics[2]					
Estimated Total Value of Coal Production	35.490 Mst	– –	$27.44 /st	**$974**	20%
Mineral Production Statistics[3,4]					
Gold	303,484 oz	– –	$610.00 /oz	$185	18%
Silver	127,617 oz	– –	$11.63 /oz	$1.5	25%
Molybdenum	37,071,000 lbs	– –	$26.50 /lb	$982	(4%)
Uranium	0 lbs	– –	$48.33 /lb	0	(100%)
Vanadium	0 lbs	– –	$8.08 /lb	0	(100%)
Industrial Minerals	– –	– –	– –	$593	3%
Estimated Total Value of Non-fuel and Uranium Minerals Production				**$1,762**	(2%)
Estimated Total Value of all Mineral and Energy Production in Colorado				**$11,609**	**(5%)**
2005 (Actual)	**Volume Produced**	**Volume Sold**	**Average Price**	**Realized Value (Millions)**	**% Change in value from 2004**
Hydrocarbon and Carbon Dioxide Production Statistics[1]					
Natural gas	1,135 Bcf	1,098 Bcf	$7.39/Mcf	$8,114	38%
Crude oil	22.79 MMbo	22.57 MMbo	$53.93/bbl	$1,217	41%
Carbon dioxide	361 Bcf	360 Bcf	$0.67/Mcf	$241	87%
Actual Total Value of Hydrocarbons and Carbon Dioxide				**$9,572**	40%
Coal Production Statistics[2]					
Actual Total Value of Coal Production	37.820 Mst	– –	$21.50/st	**$813**	2%
Mineral Production Statistics[3,4]					
Gold	352,609 oz	– –	$444.74 /oz	$157	41%
Silver	169,189 oz	– –	$7.32 /oz	$1.2	(8%)
Molybdenum	32,201,000 lbs	– –	$31.73 /lb	$1,022	194%
Uranium	255,542 lbs	– –	$28.52 /lb	$7.3	248%
Vanadium	1,374,518 lbs	– –	$17.52 /b	$24.1	1,507%
Industrial Minerals	– –	– –		$577	18%
Actual Total Value of Non-fuel and Uranium Minerals Production				**$1,789**	65%
Actual Total Value of all Mineral and Energy Production in Colorado				**$12,174**	**41%**

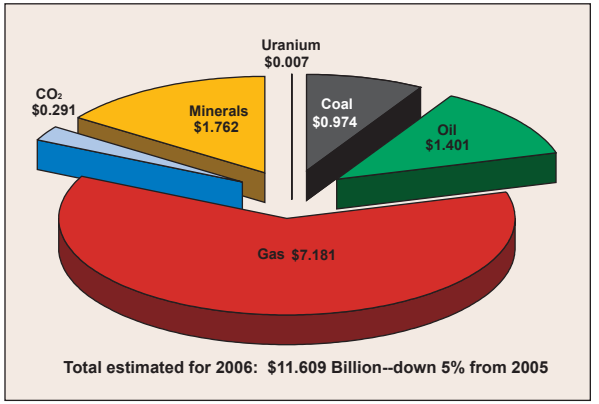

Figure 2. Mineral and energy production value ($ billion) by sector, 2006.

Table Sources: [1]Colorado Oil and Gas Commission, http://oil-gas.state.co.us/; [2]Colorado Department of Local Affairs, http://www.dola.state.co.us/LGS/FA/EMIA/miner/MinerWebTables.pdf; [3]U.S. Geological Survey Minerals Information, http://minerals.usgs.gov/minerals/pubs/mcs/; [4]Company reports and press releases.

Abbreviations: Bcf—billion cubic feet; Mcf—million cubic feet; MMbo—million barrels; bbl—barrels; Mst—million short tons; st—short tons; oz—ounces; lbs—pounds.

INTRODUCTION AND ECONOMIC FACTORS

The mineral and energy industries provide the essential elements of modern day life from gasoline for our cars; steel for our buildings, trucks, airplanes, and bridges; copper for wires and electrical parts; and aggregate for our roads. Every day, every citizen, in some way, touches or uses products provided by these industries. The Mineral Information Institute estimates that the average American will use 3.7 million pounds of minerals, metals, and fuels during an average life span of 77.6 years—that is over 47,502 pounds of materials every year for every American (fig. 3).

The mineral and energy industries in Colorado produce a wide variety of materials essential to our daily lives; coal, natural gas, and wind provide electricity; natural gas heats our homes; molybdenum hardens our steel. Sand and gravel are necessary for our homes, offices, roads, driveways, and many other uses.

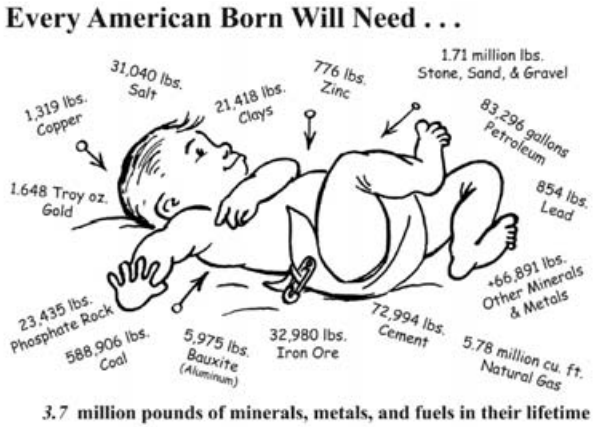

Figure 3. Mineral needs of the average American (Courtesy of the Mineral Information Institute).

The Colorado mineral and energy industries have enjoyed another year of growth; not only did production increase for several commodities, but prices for most mineral commodities, with the exception of natural gas and molybdenum, also increased. Also, employment levels increased sharply.

The Colorado Geological Survey (CGS) estimates the total value of 2006 mineral and energy production in Colorado to be **$11,609 million**—a five percent decrease from the (revised*) 2005 total value of $12,174 million (fig. 1, fig. 2, and table 1).

The value of Colorado's mineral and energy production is realized in many ways including employment, taxes, and royalties that flow back to state and local governments. The value of Colorado's share of federal mineral royalties in 2006 is $144 million—a 26 percent increase from the 2005 value of $114 million. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (figs. 4 and 5).

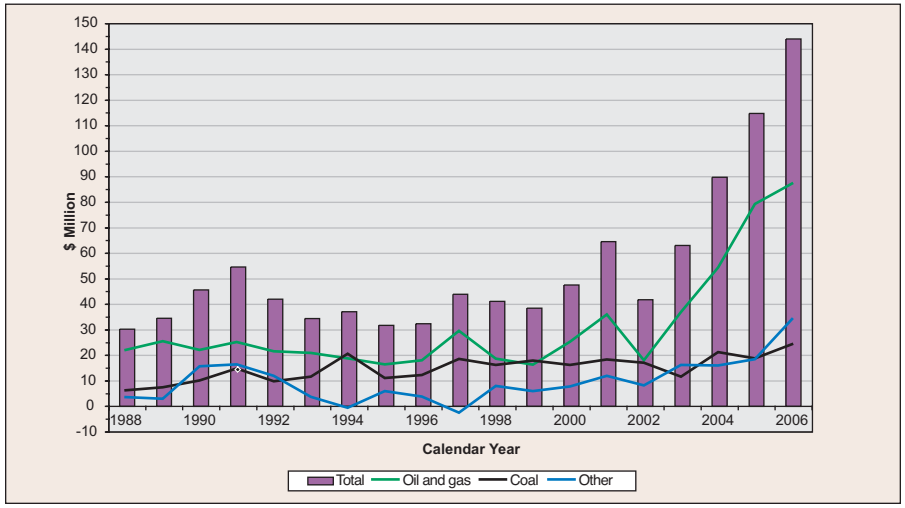

Figure 4. Federal mineral lease revenue by type, 1988–2006. Other category includes other production, rentals, and bonus payments (source: Colorado Department of Local Affairs).

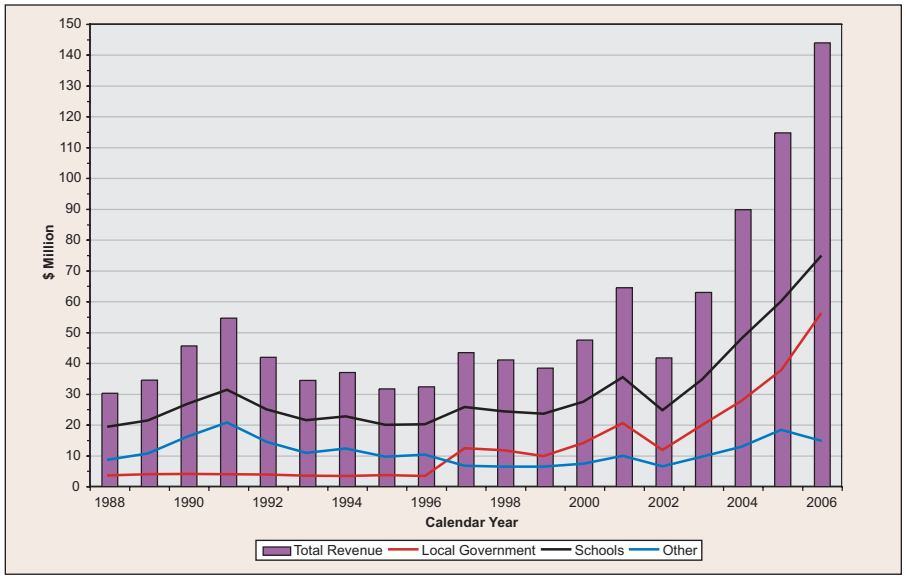

Figure 5. Federal mineral lease revenue and distribution, 1988–2006 (source: Colorado Department of Local Affairs).

Severance taxes are state taxes that are collected on the production of oil, gas, coal and certain minerals. According to Colorado law, 50 percent of the severance tax revenue flows to local governments and 50 percent flows into a state trust fund to "replace" depleted natural resources and to complete water projects. Legislation passed in 1996 allows some of the state share of severance tax to be used by agencies within the Department of Natural Resources that promote and regulate the mineral and energy industries. In fiscal year 2006, the CGS was eligible to receive $18.0 million of these funds but received only $2.1 million. Severance tax collections in fiscal year 2006 were $211.8 million—up 45 percent from the 2005 severance tax collection of $146.4 million (fig. 6).

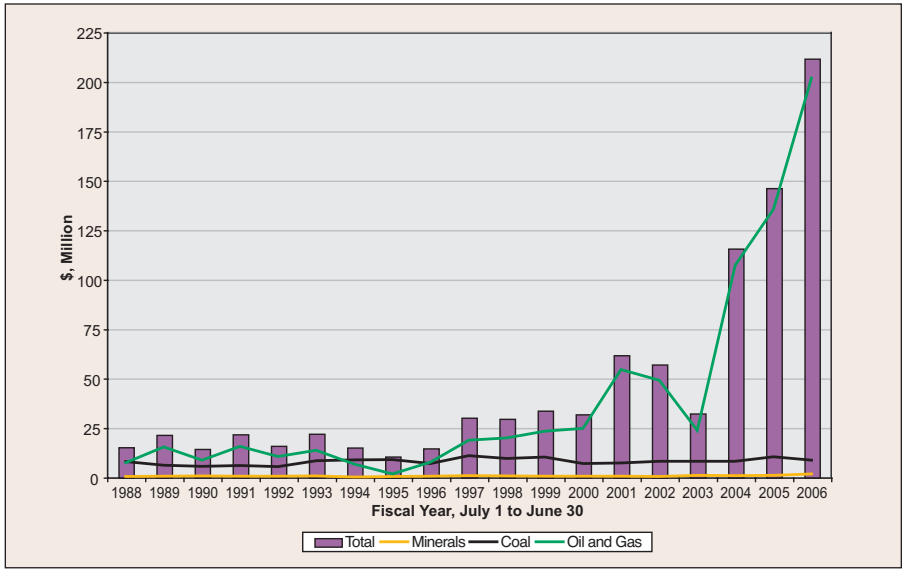

Figure 6. Colorado mineral severance tax revenue, 1988–2006 (source: Colorado Department of Local Affairs).

Estimated property taxes paid in 2006 to the counties from mineral and energy properties totaled $253 million—up 11 percent from the $227 million collected in 2005 (fig. 7). Property taxes revenues lag about two years behind the actual year of production.

In the fiscal year ending on June 30, 2006, the Colorado State Land Board received $54.291 million from mineral royalties, bonuses, and rentals on state-owned land, a new record and up 30 percent from the $41.731 million collected in fiscal year 2005. The State of Colorado owns over 4 million acres of mineral land and the revenues from these lands go to the Permanent Fund controlled by the State Land Board. Interest from this fund is distributed by the School Finance Act to the school districts of Colorado (figs. 8 and 9).

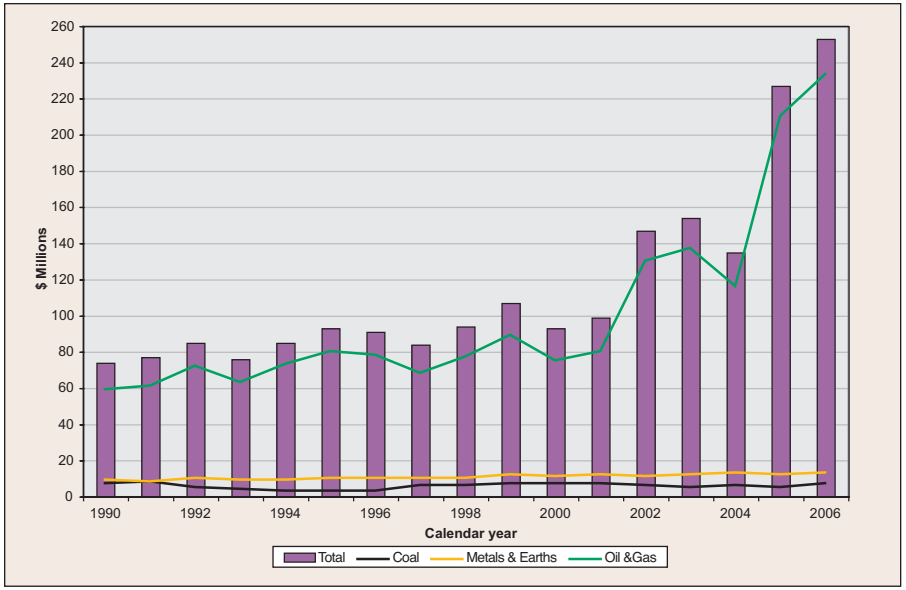

Figure 7. Property tax collections from Colorado mineral properties, 1990–2006 (source: Colorado Department of Local Affairs).

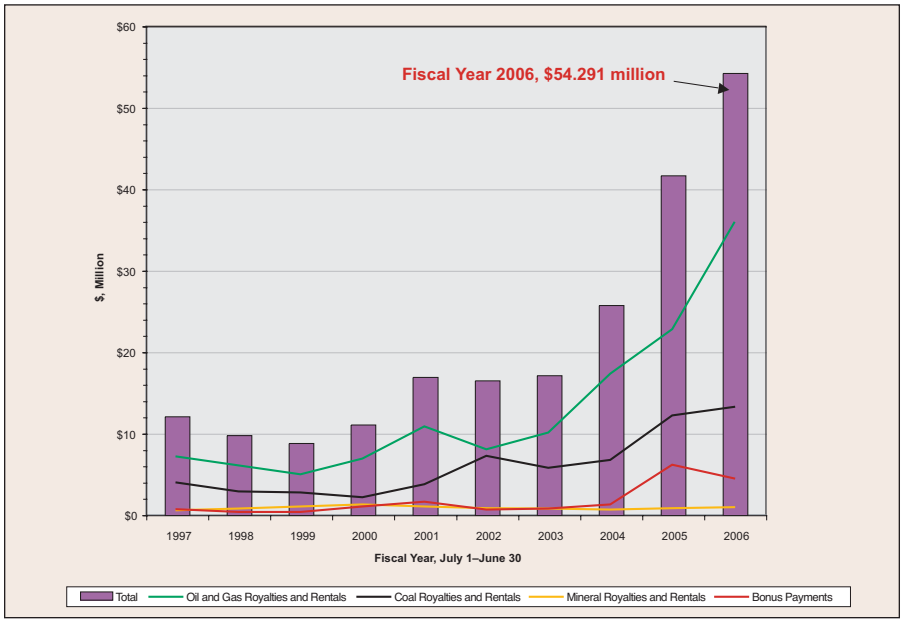

Figure 8. Colorado State Land Board Mineral Revenues, 1997–2006. Bonus payments are payments received from auctions of State mineral leases (source: Colorado State Land Board).

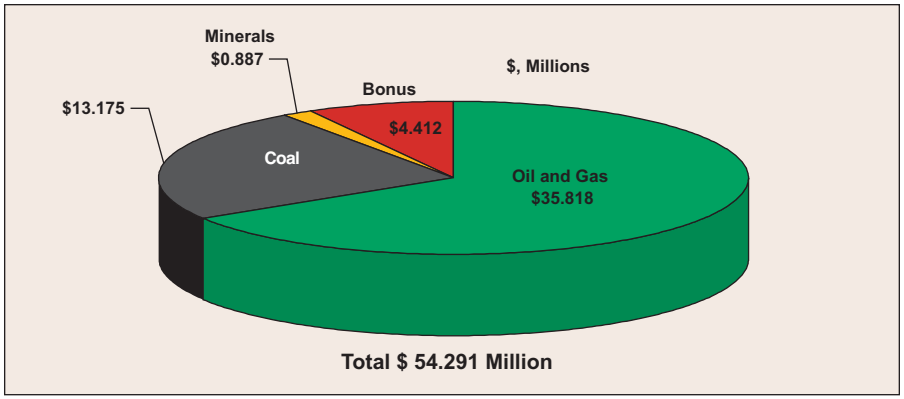

Figure 9. Colorado State Land Board mineral revenues, July 1, 2005–June 30, 2006. Bonus payments are payments received from auctions of State mineral leases (source: Colorado State Land Board).

The Colorado Department of Labor and Employment tracks employment trends for the state. Employment statistics for the mining and oil and gas extraction industries are included in their Mining category. This sector grew 70 percent (from 12,880 to 21,900) between 2000 and the 3rd quarter of 2006 (fig. 10). The Colorado Business Economic Outlook Forum annual report for 2006 states that about one-third of the employees in this supersector work in each of the following areas: oil and gas extraction, mining, and support activities related to both oil and gas and mining industries. The 23 percent growth in employment from 17,815 in 2005 to 21,900 in 2006 has resulted in a new ten-year high. Wages for workers in the oil and gas and mining business sectors are among the highest in the state and bring a much-needed source of wealth to the rural parts of Colorado. According to the Colorado Department of Labor and Employment, the average annual wage through the 2nd quarter of 2006 for workers in the oil and gas and mining industries was $85,280; about twice the average of $41,288 for all statewide job categories (fig. 10).

Figure 10. Colorado mineral and energy industry employment and wages, 1995–2006 (source: Colorado Department of Labor and Employment).

CONVENTIONAL ENERGY RESOURCES: OIL AND NATURAL GAS

SUMMARY

Colorado's oil and natural gas industry experienced a modest decline in production value during 2006 compared with the rapid growth observed in recent years (fig. 11). This drop in value is primarily related to the volatility in natural gas prices.

The total value of oil and gas production in 2006 is estimated at $8.58 billion, a nine percent decrease over the revised 2005 value of $9.33 billion. The value of oil production increased 15 percent due in large part to the 12 percent increase in the average oil price. In contrast, the average price in gas declined 20 percent, offsetting the 6.5 percent increase in natural gas production.

COMMODITY PRICES

Oil and natural gas prices for Colorado are tracked by the Colorado Oil and Gas Conservation Commission (COGCC) and made publicly available via their website. Colorado's so-called "oil price" is actually a computed oil price composite index. This weighted index is based on the geographic quadrant of the state in which the production occurs (NW, SW, NE, or SE) and the refinery that is purchasing the production (Chevron Texaco, Shell, Suncor or Valero). Natural gas liquids, condensate, and crude oil are referred to, in the aggregate, as oil.

Colorado Weighted Average Oil Price Composite Index =
0.35 NW (Chevron Texaco) + 0.05 SW (Shell) + 0.40 NE (Suncor) + 0.20 SE (Valero)

The state's oil index has shown strong growth in recent years. Since early 2002, oil prices have increased four-fold from about $17 per barrel to nearly $68 in July 2006 (fig. 12). Prices fell in the last half of the year resulting in an average oil price for 2006 of $60.32 per barrel.

As with Colorado's oil index, the often-quoted "gas price" is actually a computed composite index. This weighted index is based on the geographic area of the state in which the production occurs and the pipeline infrastructure that it will supply. Natural gas is priced based on its British thermal units (Btu)-content, a price that decreases with increasing concentrations of non-methane contaminates.

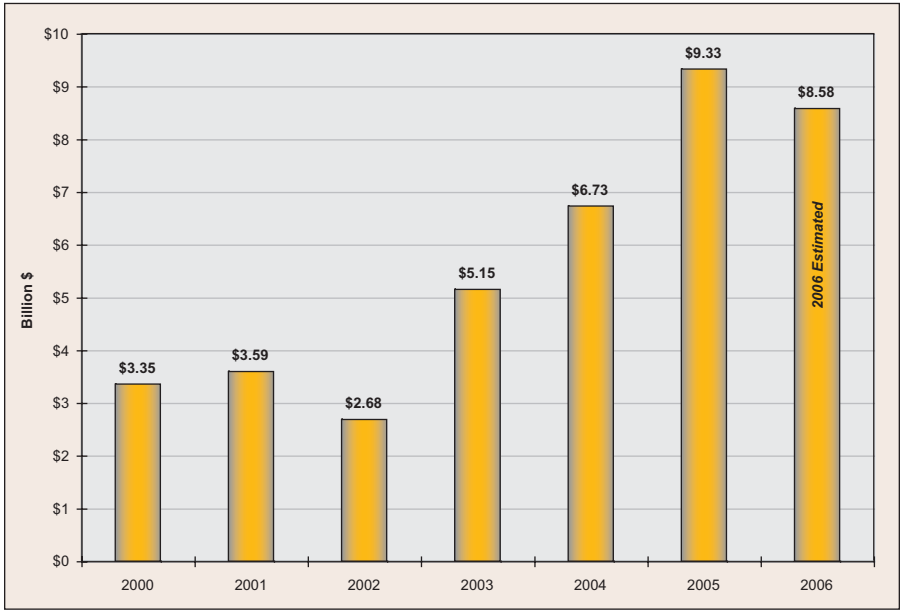

Figure 11. Annual production value for oil and natural gas in Colorado, 2000–2006 (Colorado Oil and Gas Conservation Commission, 2007).

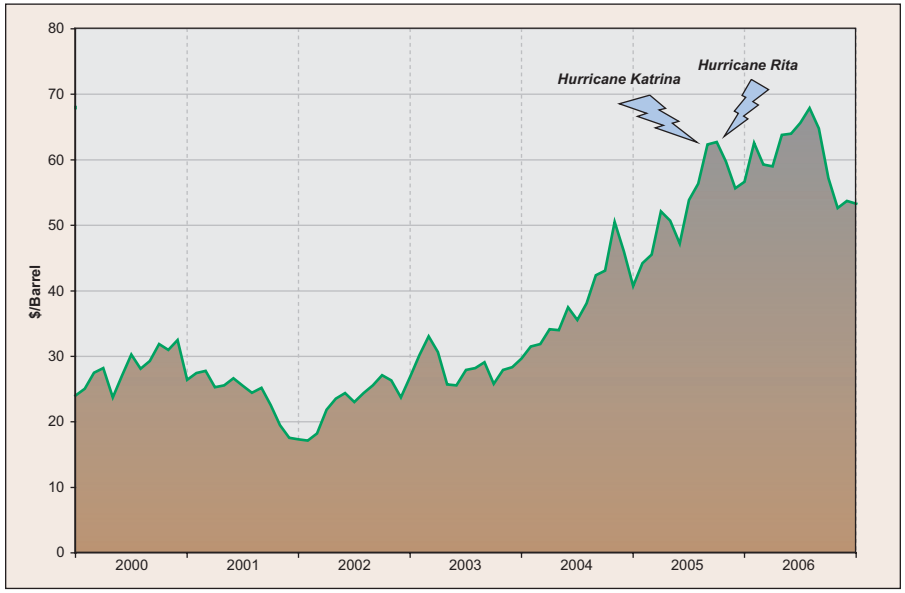

Figure 12. Colorado weighted average oil price composite index; monthly data for January 2000–December 2006 (Colorado Oil and Gas Conservation Commission, 2007).

Colorado Weighted Average Gas Price Composite Index =
0.20 Rocky Mountains (Northwest Pipeline) +
0.50 San Juan Basin (El Paso Natural Gas Pipeline) +
0.30 Rocky Mountains (Colorado Interstate Gas Pipeline)

The state's gas index has shown strong recovery in recent years, particularly since 2002. Gas prices have increased from an average of $2.29 per million Btu in 2002 to $6.94 in 2005, representing a three-fold increase in four years. Since the nation-wide price spikes resulting from the 2005 Gulf Coast hurricane season, gas prices in Colorado have declined, averaging $5.77 per million Btu in 2006 (fig. 13).

The opening of the Kern River pipeline expansion in mid-2003 provided Colorado operators (among others in the Rockies) the opportunity to compete with markets in California. This increased competition provided stronger gas prices for Colorado (fig. 13). Prior to the opening of the Kern River expansion, Colorado gas prices were falling because more gas was being produced in the state than there was pipeline capacity to transport it to other markets. The post-Kern River pipeline period saw a significant expansion in the gas market, yielding more favorable prices for Colorado producers.

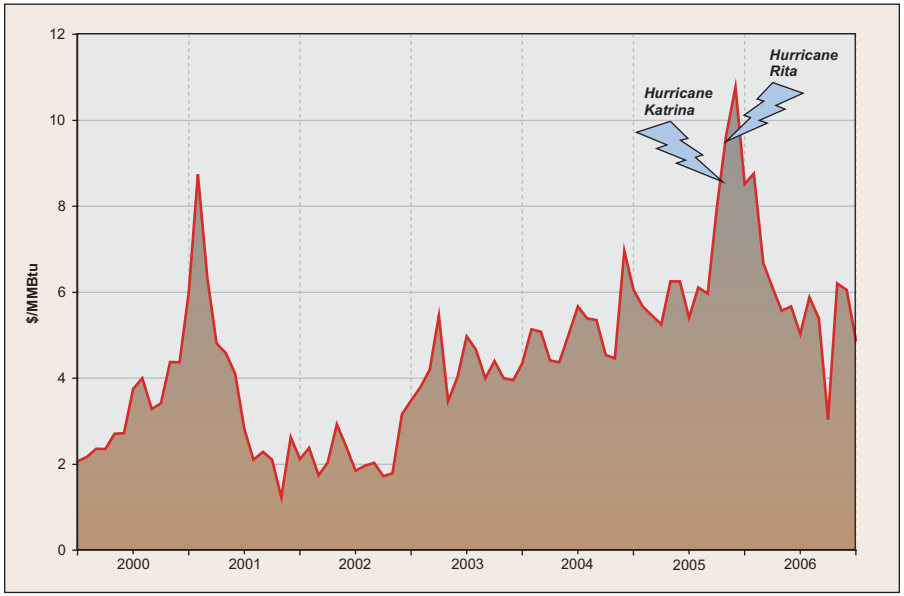

Figure 13. Colorado weighted average gas price composite index; monthly data for January 2000–December 2006; MMBtu = Million British Thermal Units (Colorado Oil and Gas Conservation Commission, 2007).

OIL AND GAS PRODUCTION VOLUME AND VALUE

Since 2002, the energy industry has benefited from rising prices and production volumes of oil and natural gas. The combined value of oil and natural gas production in Colorado is estimated at $8.6 billion for 2006, an eight percent decline from the state's record-breaking high in 2005 of $9.3 billion. Of this value, $7.2 billion (84 percent) is from the sale of natural gas, with about 40 percent of this value from coalbed methane.

For the fourth consecutive year, natural gas production in Colorado exceeded 1 trillion cubic feet (Tcf) (fig. 14). Natural gas production in 2006 is estimated to be 1.21 Tcf which is a 6.1 percent increase over the 1.14 Tcf produced in 2005. Colorado's annual gas production in 2005 represented six percent of total U.S. production, making Colorado the 7th largest gas producing state in the nation (Energy Information Administration, 2006). Since separate reporting for coalbed methane began in 1990, coalbed methane production grew to represent about one-half of the state's natural gas production until the last three years. Since 2003, coalbed methane production has declined while conventional gas production has continued to steadily increase (fig. 14). In 2006, coalbed methane production is estimated to be 480 billion cubic feet (Bcf) which is 7.1 percent below the peak of 514 Bcf reported in 2003.

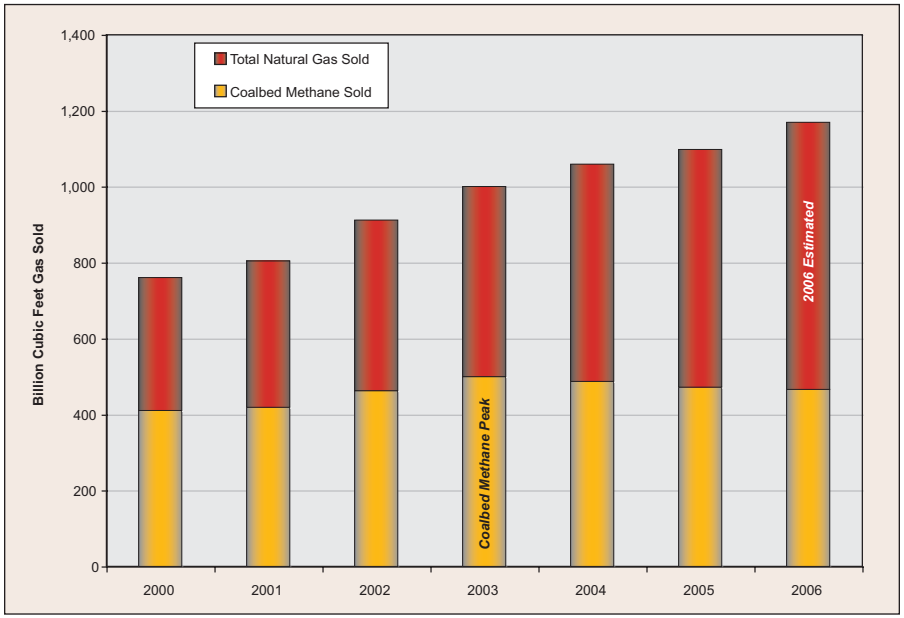

Figure 14. Colorado natural gas production value (Colorado Oil and Gas Conservation Commission, 2007).

Figure 15. Value of Colorado natural gas production (Colorado Oil and Gas Conservation Commission, 2007).

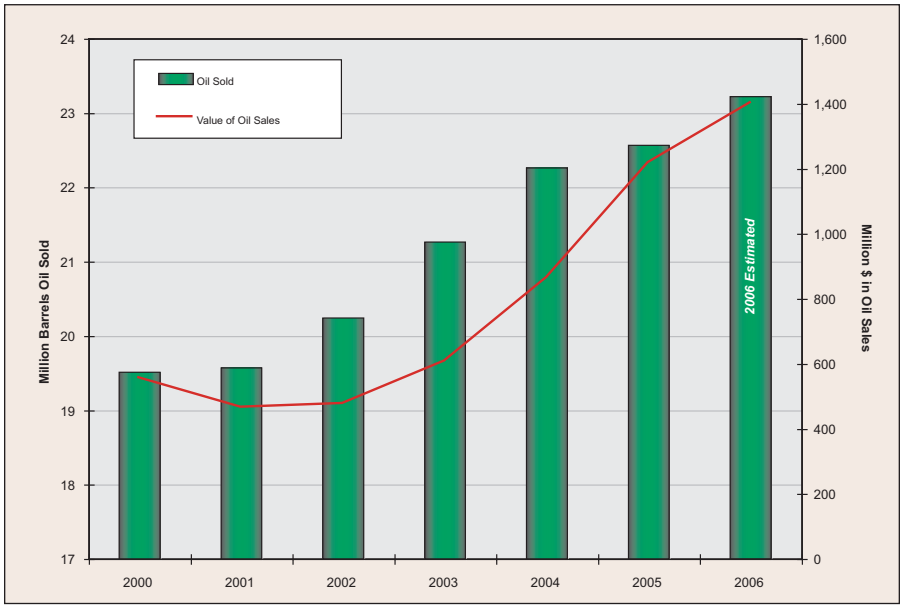

Figure 16. Colorado oil production and value (Colorado Oil and Gas Conservation Commission, 2007).

Because of the tremendous boom in Rockies' gas exploration and development, Colorado's gas production has grown nearly 57 percent since 2000; from 772 Bcf to an estimated 1.21 Tcf for 2006 (fig. 14). By contrast, the value of that production has increased from $2.8 billion to an estimated $7.2 billion during the same period, more than a 2½-fold increase in the value of the state's gas production (fig. 15).

Oil production in 2006 is estimated to be 23.5 million barrels, a 3.1 percent increase over the 22.8 million barrels produced in 2005 (fig. 16). Although growth in oil production has been slow and steady since 2000, strong oil prices continue to drive up its value at a faster rate than otherwise expected from production increases. The value of 2006 oil production is estimated to be $1.4 billion compared to the $1.2 billion in 2005. This represents an increase of nearly 17 percent for the year, and a three-fold increase since hitting a low of $464 million in 2001, just five years ago.

COUNTY RANKINGS

Thirty-seven (or 57 percent) of Colorado's 65 counties produce either oil or natural gas, often both. For the purpose of ranking each county's contribution to the total value of the state's production, the sales volumes for each county have been assigned a value using the average annual composite oil and gas price indices ($60.32 per barrel oil and $6.14 per thousand cubic feet gas [Mcf], respectively). (The sales volumes for the last half of 2006 are incomplete at the time this ranking is determined.) Based on the resulting production values computed for 2006, Colorado has three counties in which the annual production value is estimated to exceed $1 billion (La Plata, Garfield, and Weld) and three counties in which the annual production value is estimated at $100 million or more but less than $1 billion (Rio Blanco, Las Animas, and Yuma) (fig. 17). The combined production value for these six counties represents 91 percent of the total production value for Colorado.

A significant portion of this value results from the production of natural gas. The same six counties that top the rankings in total production value account for 93 percent of the total natural gas production sold for the state and nearly 78 percent of the total oil production sold. The top ranking counties in the sale of natural gas production for 2006 are La Plata, Garfield, and Weld, each with sales in excess of 100 Bcf for the year; Las Animas, Rio Blanco, Yuma, San Miguel, and Moffat counties each had sales of natural gas production in excess of 10 Bcf during the same period (fig. 18). The top ranking counties in oil production sold in 2006 are Weld, Rio Blanco, and Cheyenne with each reporting the sale of more than 1 million barrels of oil or 82 percent of the oil sold in Colorado (fig. 19).

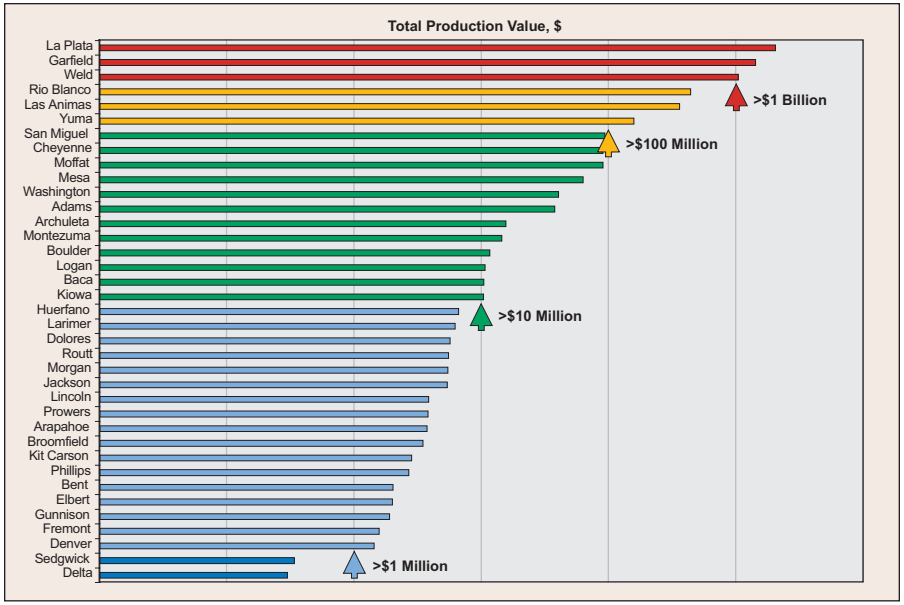

Figure 17. Oil and natural gas production value by county for 2006 (Colorado Oil and Gas Conservation Commission, 2007). Note the scale is logarithmic.

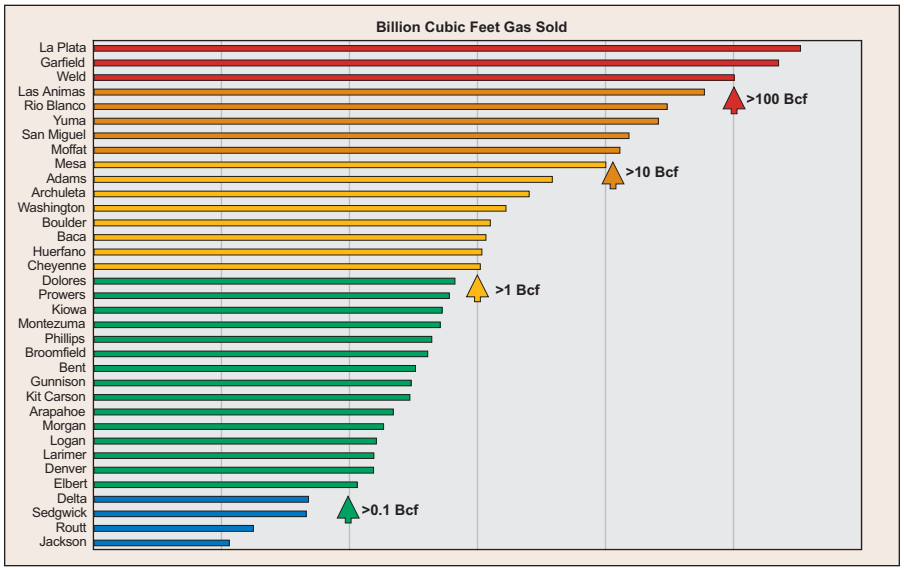

Figure 18. Total natural gas production sold by county in 2006 (Colorado Oil and Gas Conservation Commission, 2007). Note the scale is logarithmic.

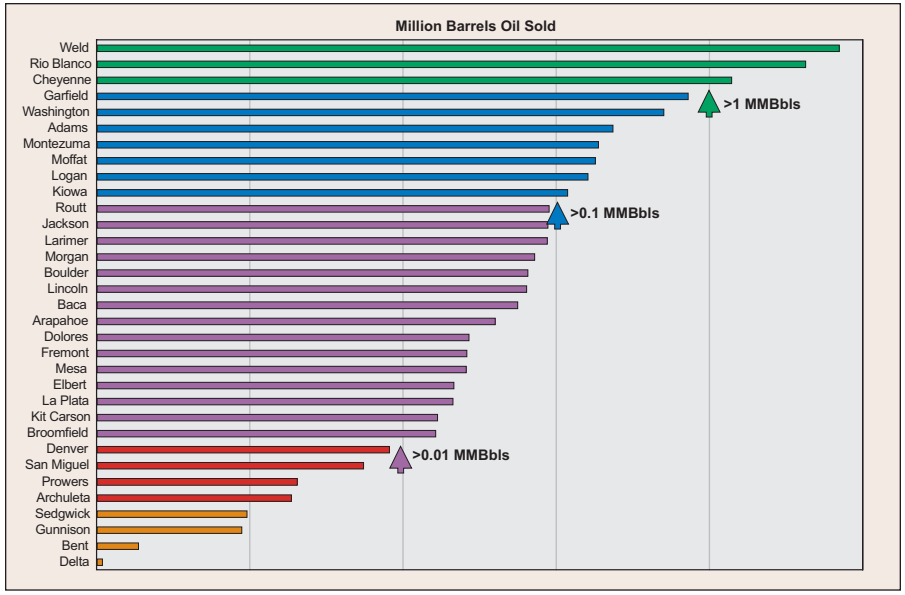

Figure 19. Total oil production sold by county in 2006 (Colorado Oil and Gas Conservation Commission, 2007). Note the scale is logarithmic.

FIELD RANKINGS AND ACTIVITY

The county rankings reflect the diversity in Colorado's oil and gas resource base. La Plata County is home to Ignacio–Blanco, the largest gas producing field in Colorado (fig. 20). Nearly 90 percent of the gas sold in La Plata County is produced from coal beds of the Late Cretaceous Fruitland Formation. Oil and gas production also occur from deeper horizons within the basin's Cretaceous sequence, including the Lewis Shale, Mesaverde Group, Mancos Shale, and Dakota Sandstone. The San Juan Basin Gas Area of Colorado and New Mexico ranked as the leading U.S. natural gas area in both production and proved reserves in 2005 (Energy Information Administration, 2006).

The Wattenberg field in the Denver Basin ranked as the 7th largest field in the U.S. in terms of gas proved reserves and 9th in terms of gas production in 2005 (Energy Information Administration, 2006). Wattenberg ranked 26th in oil production and 18th in oil proved reserves in 2005. Although the Wattenberg field straddles several counties within the Denver Basin, a significant portion of the field's production is located in Weld County (fig. 20). The western part of the basin, which is located along the eastern edge of the Front Range, is rich in both oil and gas resources. The vast majority of production comes from the Cretaceous Dakota Group's Muddy J Sandstone and the Niobrara–Codell sequence. Production also occurs from the D Sandstone and the fractured Pierre Shale. During 2006,

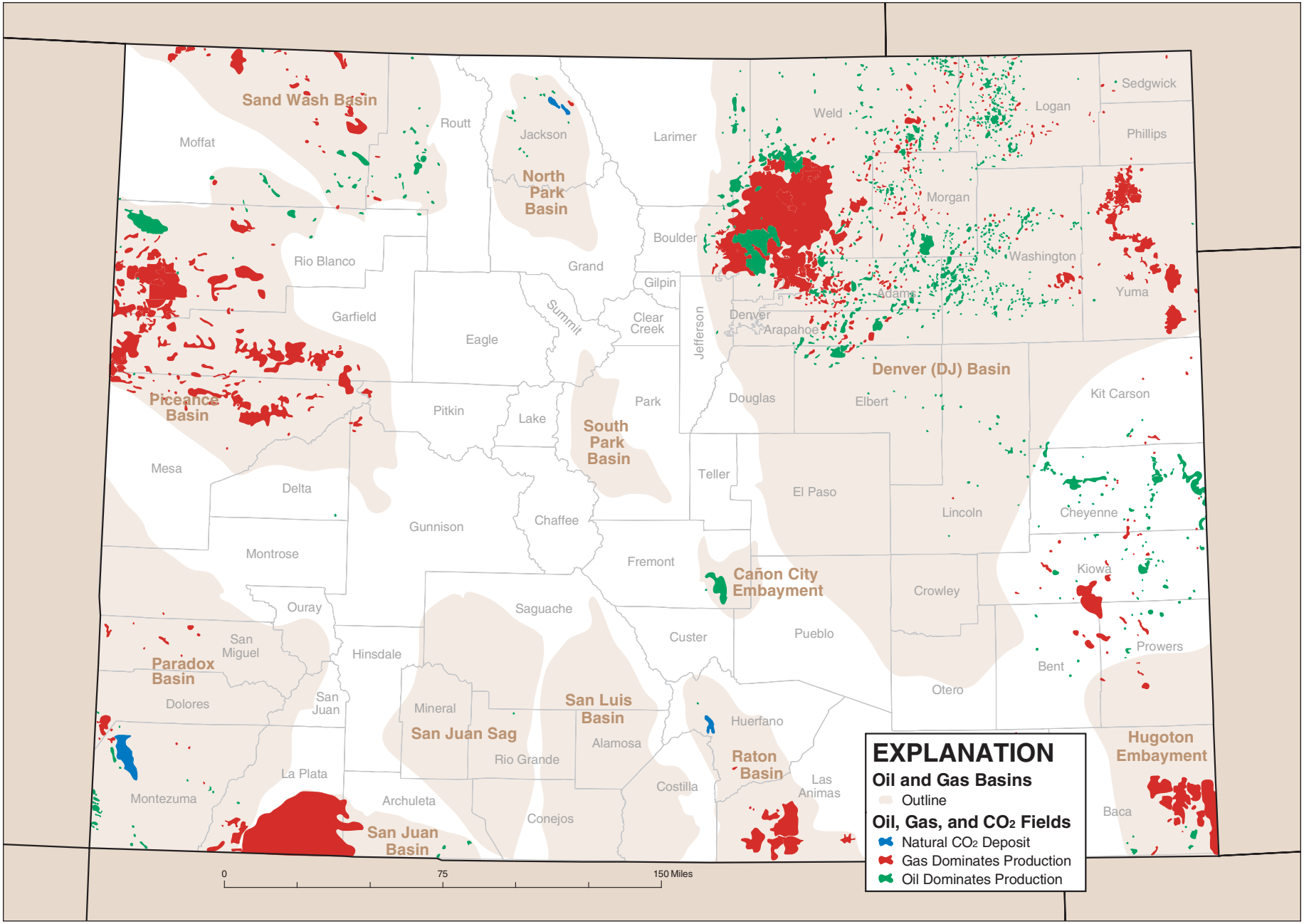

Figure 20. Oil, gas, and carbon dioxide (CO_2) producing fields in Colorado.

the Wattenberg field's production averaged about 27,000 barrels of oil and 0.44 Bcf of gas each day. The liquid production is comprised of approximately 45 percent crude oil, 23 percent gas condensate, and 32 percent natural gas liquids (Wally O'Connell, Kerr-McGee, personal communication). Within the eastern portion of the Denver Basin, the relatively shallow Cretaceous Niobrara Chalk is now making a significant contribution through the production of biogenic gas—a play that is centered in Yuma County.

The Piceance Basin has recently been referred to as the "Persian Gulf of natural gas" (*Denver Post*, March 10, 2006). This remarkable center of natural gas drilling activity is located in Garfield and Rio Blanco counties and is receiving nationwide attention because of its strategically important gas resources (fig. 20). The Piceance Basin hosts four fields with natural gas proved reserves in the nation's "Top 50" list of fields (Energy Information Administration, 2006). All four are located along Interstate Highway 70 in Garfield County. Significant gas production occurs from the Paleocene–Late Cretaceous Fort Union Formation and the Late Cretaceous Mesaverde Group sandstones and coalbeds. In addition, significant oil production occurs from a thick interval spanning the Cretaceous to Pennsylvanian, including the Mancos Shale, Morrison Formation, Entrada Sandstone, the Shinarump Member of the Chinle Formation, and the Weber Sandstone. The Rangely field, which is located in the northwestern Piceance Basin, produces from the prolific Permo-Pennsylvanian Weber Sandstone and accounts for Rio Blanco County ranking second in the sale of oil production for the state. Rangely is one of the largest oil fields in the Rocky Mountains, ranking 61st in the U.S. in terms of oil proved reserves and 51st in terms of oil production in 2005 (Energy Information Administration, 2006).

There is also intense development activity in southeastern–south central Colorado. Oil (and some associated gas) production in Cheyenne County occurs from Mississippian- and Pennsylvanian-age sandstone and limestone reservoirs along the Las Animas Arch that separates the Hugoton Embayment from the Denver Basin (fig. 20). The Raton Basin located in western Las Animas County is the site of an aggressive coalbed methane play within the Tertiary and Late Cretaceous Raton and Vermejo Formations. The Raton Basin Gas Area of Colorado and New Mexico ranked 11th in the nation in proved gas reserves and 16th in gas production in 2005 (Energy Information Administration, 2006).

San Miguel County in the northern Paradox Basin reports the sale of more than 15 Bcf of gas produced from the Permo-Pennsylvanian Cutler and Hermosa Groups and the deeper Mississippian Leadville Limestone.

Moffat County includes both the northernmost part of the Piceance Basin and the western two-thirds of the Sand Wash Basin. Oil and gas sales are reported from numerous intervals from the Paleocene to deeper Pennsylvanian-age rocks. These include the Paleocene-Cretaceous Wasatch-Fort Union Formations, Cretaceous Lance-Fox Hills-Lewis-Almond interval, Mesaverde Group sandstones, Mancos-Niobrara-Mowry shales, Dakota Group, Jurassic Morrison-Sundance-Entrada-Nugget sequence, Permo-Triassic Shinarump-Moenkopi-Phosphoria formations, and Permo-Pennsylvanian Weber-Minturn formations.

DRILLING ACTIVITY

The COGCC reports 6,474 applications for permit to drill (APDs) were received during 2006, representing nearly a 26 percent increase over the 5,148 APDs received in 2005 (fig. 21). Of those received in 2006, 247 were withdrawn and 6,221 of the remaining applications were approved; six remained to be processed at year-end. The vast majority of the applications approved during 2006 were for drilling new wells or sidetracking existing wellbores; that is, 94 percent or 5,849 permits were approved for drilling new wells (fig. 22). The remaining 372 permits consisted of requests for deepening, recompleting, or re-entering existing wellbores.

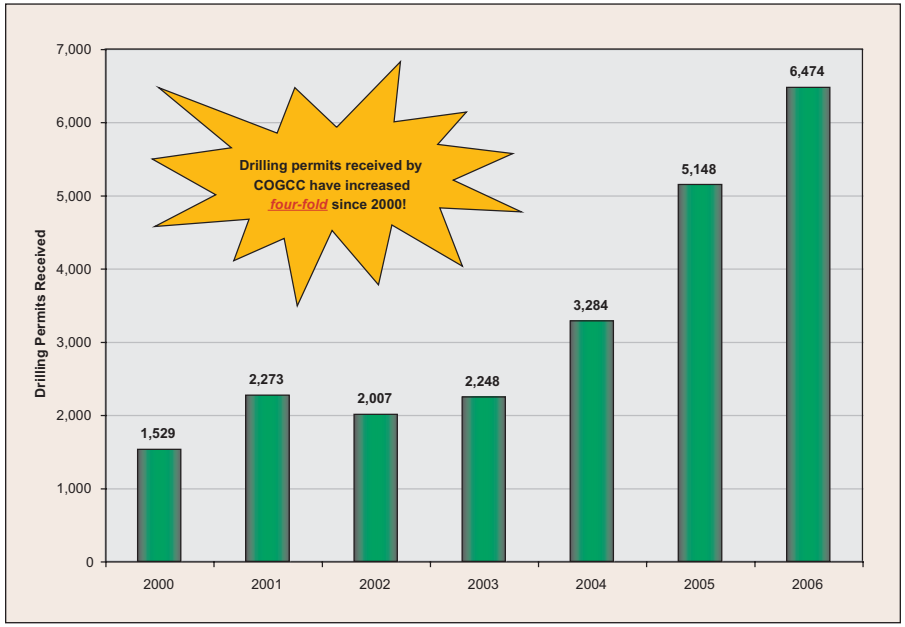

Figure 21. Drilling permits received by the Colorado Oil and Gas Conservation Commission since 2000.

The three counties for which the most drilling permits were approved in 2006 are Garfield, Weld, and Las Animas (fig. 23) and reflect the strong focus of exploration and development efforts in the Piceance, Denver, and Raton basins, respectively. Of the total 6,221 applications that were approved in 2006, 91.5 percent or 5,689 were for drilling activity in the Piceance, Denver, and Raton basins (fig. 24). An active infill drilling program in the Denver Basin edged out the Piceance

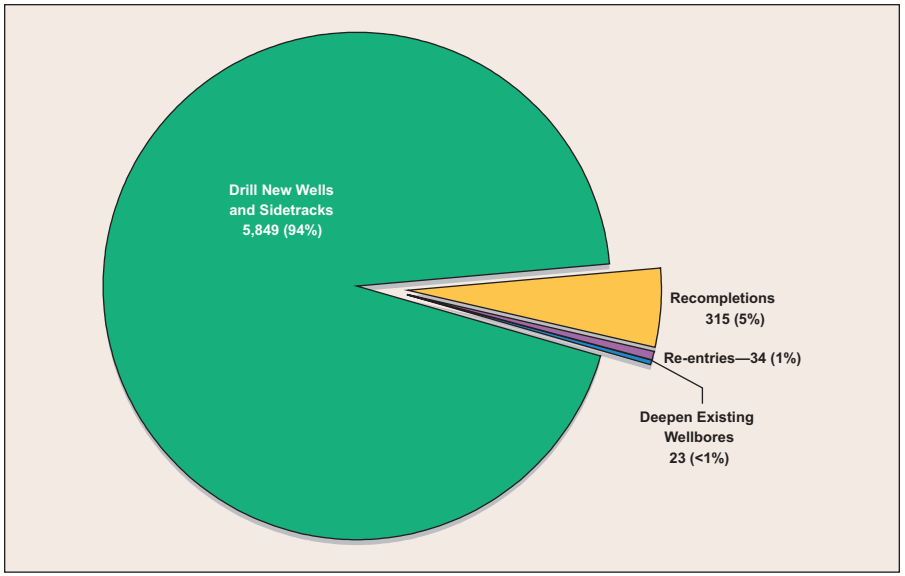

Figure 22. APDs approved during 2006 by type (Colorado Oil and Gas Conservation Commission, 2007).

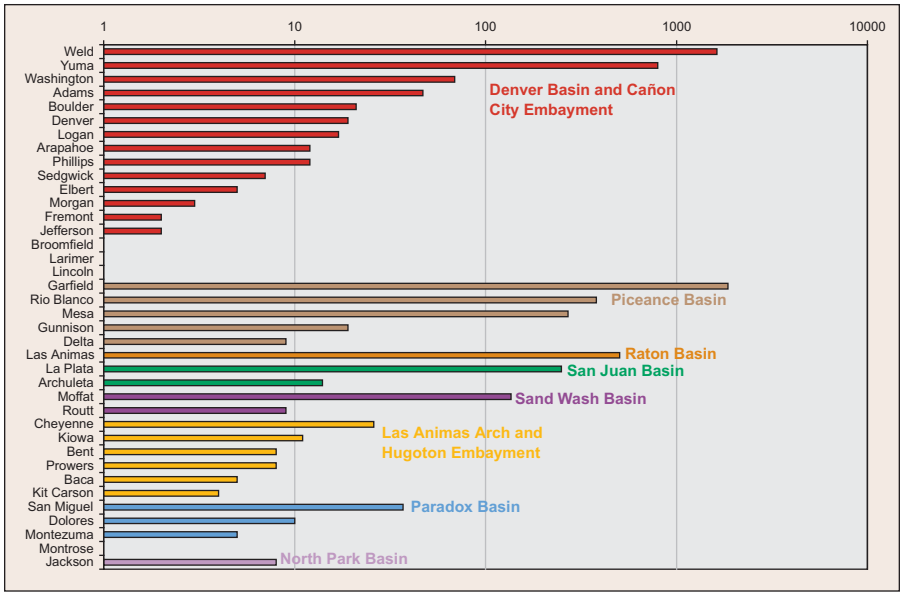

Figure 23. APDs approved in 2006 by county and basin (Colorado Oil and Gas Conservation Commission, 2007).

for the most permits approved for 2006. In addition to the proposed drilling activity in Colorado's more mature areas such as the San Juan and Paradox basins, applications were also approved in 2006 for emerging resource areas such as the coalbed methane potential in the Sand Wash and North Park basins. In fact, the permits for the Sand Wash Basin more than doubled in 2006, increasing to 145 over the 70 in 2005.

The average weekly rotary drill rig count for Colorado was 89 during 2006, up more than 20 percent from the average of 74 for 2005 (Baker Hughes, 2007). This average represents about 5.8 percent of the total 1,537 onshore rigs operating in the U.S. during 2006.

PI/Dwights (IHS Inc.) reports 2,513 total well completions for 2006, down 25.5 percent from the total of 3,153 reported for 2005. Seven operators accounted for nearly two-thirds of all well completions in the 2006-drilling program, most of which focused on development drilling in the Denver and Piceance basins (table 2).

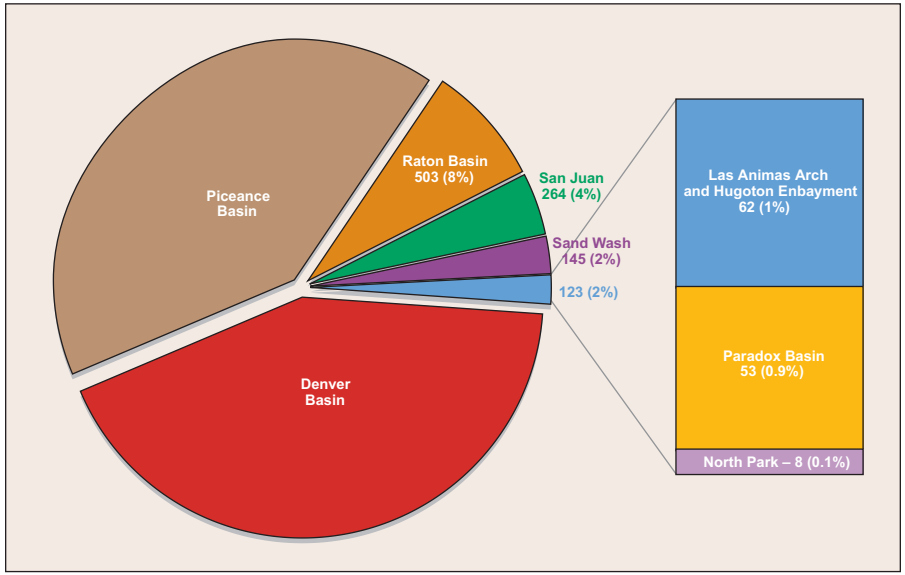

Figure 24. APDs approved in 2006 by basin (Colorado Oil and Gas Conservation Commission, 2007).

Table 2. Ranking of top operators with more than 100 well completions reported to PI/Dwights for 2006.

Operator	West DJ	Piceance	East DJ	Raton	Paradox	Total
Noble Energy/ Patina	368	6	12			386
Williams Production		303				303
Berry Petroleum		14	205			219
EnCana Oil & Gas		33	167		10	210
Kerr-McGee	207					207
Pioneer/Evergreen		15		155		170
Petroleum Development	115	29	11			155
Basin Sub Total	**723**	**534**	**228**	**155**	**10**	**1,650**

RESERVES

The Energy Information Administration (EIA) defines "proved reserves" as those volumes of oil and gas that geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Proved reserves are either proved producing or proved non-producing. Non-producing reserves are those that remain in the reservoir because they were not drilled during the report year. Non-producing reserves may represent a substantial fraction of total proved reserves. Reserves data discussed below for crude oil, natural gas, and coalbed methane are reported by the EIA and lag by one year the production and price information available from the COGCC.

Crude Oil

It is estimated that Colorado had 246.2 million barrels of proved reserves of crude oil as of December 31, 2005, which represents an increase of 9.4 percent or 21.2 million barrels from the end of 2004 (fig. 25) (Energy Information Administration, 2006; Colorado Oil and Gas Conservation Commission, 2007). Net reserves additions of crude oil in Colorado replaced 93 percent of production in 2005; that is, 21.2 million barrels in net gain in reserves versus 22.8 million barrels in production. Nationally, crude oil proved reserves rose for the first time in three years, increasing by two percent above the 2004 level; that is, 21.8 billion barrels in 2005 over 21.4 billion barrels in 2004 (Energy Information Administration, 2006). Net reserves additions in the U.S. replaced 122 percent of the 2005 production.

Colorado's increase in crude oil proved reserves resulted primarily from acquisitions and extensions to existing oil fields; no new field discoveries or new reservoir discoveries in old fields were reported for 2005 (Energy Information Administration, 2006). There was some adjustment to previously reported reserves which is common as infill wells are drilled, well performance is analyzed, new

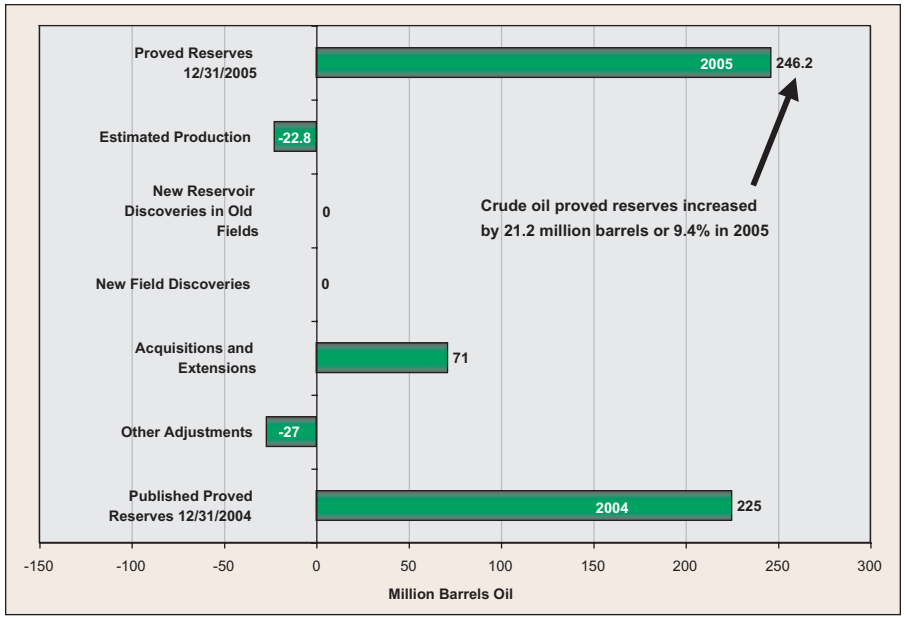

Figure 25. Colorado crude oil proved reserves, reserves changes, and production for 2005 (Energy Information Administration, 2006; Colorado Oil and Gas Conservation Commission, 2007).

technology is applied, or economic conditions change. The largest upward move in oil reserves is related to the continued development efforts in the Greater Wattenberg Area of the Denver Basin.

Not all proved reserves of crude oil reported in 2005 were producing. Colorado reported 74 million barrels of proved crude oil reserves in non-producing status, 19.4 percent more than the 62 million barrels reported in 2004 (Energy Information Administration, 2006; Energy Information Administration, 2005). In addition, Colorado reported 36 million barrels of proved lease condensate reserves in non-producing status, 8.3 percent less more than the 39 million barrels reported in 2004. Non-producing reserves are those awaiting well workovers, the drilling of extensions or additional development wells, installation of production or pipeline facilities, and depletion of other zones or reservoirs before recompletions in reservoirs not currently open to production.

The top 100 oil fields account for over two-thirds of U.S. crude oil proved reserves. The EIA (2006) ranked the top 100 oil fields based on reserves reported for 2005. Colorado has two fields in the top 100—Wattenberg and Rangely. The Wattenberg field, discovered in 1970 in the Denver Basin, ranked as the 18th largest oil field in the nation based on liquids proved reserves (liquids includes both crude oil and lease condensate). The Rangely field, discovered in 1902 in the Piceance Basin, ranked as the 61st largest oil field based on liquids proved reserves.

Natural Gas

The EIA defines "dry" natural gas as the actual or calculated volumes of natural gas that remain after: (1) the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field, and/or plant separation), and (2) any volumes of non-hydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable.

Proved reserves of U.S. natural gas increased by six percent in 2005, making it the largest annual increase in natural gas proved reserves since 1970 (Energy Information Administration, 2006). Total net reserves additions for the onshore lower 48 States were 12.1 Tcf, offsetting the 10 percent decline in gas reserves reported for the Gulf of Mexico Federal Offshore because of 2005 hurricane damage (Energy Information Administration, 2006). Colorado was one of two states that led the nation in 2005 natural gas reserves additions with notable increases in the Ignacio-Blanco Field (tight sands and coalbeds); the other was the Texas Barnett Shale play at Newark East Field (Energy Information Administration, 2006).

Seven areas account for 78 percent of the nation's dry natural gas proved reserves; among this list is Colorado with eight percent of total U.S. gas reserves (table 3). The EIA (2006) reports that Colorado dry natural gas proved reserves increased by 1.8 Tcf during 2005 which represents a 12.4 percent increase from the 14.7 Tcf reported for 2004 (fig. 26).

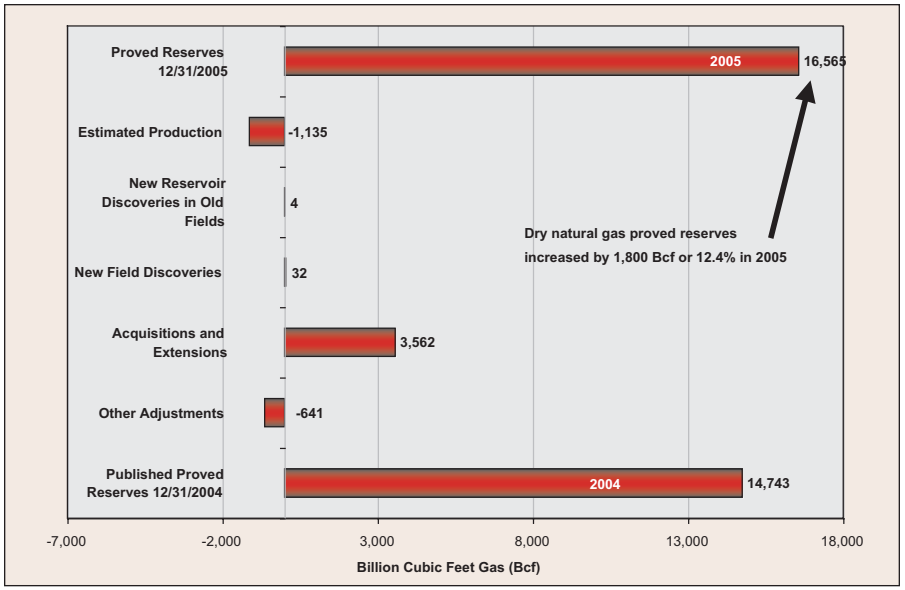

Figure 26. Colorado dry natural gas proved reserves, reserves changes, and production for 2005 (Energy Information Administration, 2006; Colorado Oil and Gas Conservation Commission, 2007).

Table 3. Ranking of top U.S. gas reserve areas for 2006.

Area	Percent of U.S. Gas Reserves	Proved Gas Reserves, Tcf
Texas	28	56.5
Wyoming	12	23.8
New Mexico	9	18.2
Oklahoma	8	17.1
Gulf of Mexico Federal Offshore	8	17.0
Colorado	8	16.6
Louisiana	5	10.4
Area Total	**78**	**159.6**

Extensions of existing gas fields were the largest component in total discoveries in 2005 (Energy Information Administration, 2006). Colorado ranked 4th in the nation in 2005 extensions, representing nine percent of the U.S. total of 21.1 Tcf. Colorado also ranked 3rd in the nation with 32 Bcf in new field discoveries in 2005 or three percent of the U.S. total.

Colorado reported 5.0 Tcf of total proved gas reserves in non-producing status in 2005, 13.6 percent more than the 4.4 Tcf reported in 2004 (Energy Information Administration, 2006; Energy Information Administration, 2005). These "behind pipe" reserves consisted of 4.3 Tcf of non-associated gas and 0.7 Tcf of associated-dissolved gas. Non-associated natural gas is that which is not in contact with significant quantities of crude oil in the reservoir. Associated-dissolved natural gas is the combined volume of natural gas, which occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved).

Parts of eight of the nation's largest 100 gas fields are in Colorado—San Juan Basin Gas Area, the Wattenberg field in the Denver Basin, Raton Basin Gas Area, and the Grand Valley, Mamm Creek, Parachute, Rulison, and Piceance Creek fields in the Piceance Basin (Energy Information Administration, 2006) (table 4). Two of these—the San Juan and Raton Basin Gas Areas are shared with New Mexico. Of these gas-rich areas, the San Juan Basin Gas Area and Wattenberg field rank in the top 10 in the U.S. Most notably, the Ignacio Blanco/ Blanco gas fields of the San Juan Basin Gas Area in Colorado and New Mexico represent the largest proved gas reserves for the entire nation and also have the highest combined gas production of 1.4 Tcf estimated for 2005.

Table 4. Colorado gas fields ranked in top 100 U.S. by proved gas reserves and gas production in 2005.

Field Name	Location	Discovery	Reserves Rank	Production Rank	Production Volume, Bcf
San Juan Basin Gas Area	CO & NM	1927	1	1	1,397.0
Wattenberg	CO	1970	7	9	179.1
Raton Basin Gas Area	CO & NM	1998	11	16	120.9
Grand Valley	CO	1985	22	34	63.0
Mamm Creek	CO	1959	24	21	95.5
Parachute	CO	1985	28	45	51.3
Rulison	CO	1958	30	38	54.7
Piceance Creek	CO	1930	62	>100	5.9

Coalbed Methane

Nationally, proved reserves of coalbed methane increased to 19.9 Tcf in 2005, an 8.2 percent increase from the 2004 level of 18.4 Tcf (Energy Information Administration, 2006). These reserves are included in the natural gas reserves discussed in the previous section. Coalbed methane accounted for 10 percent of all 2005 dry natural gas reserves in the U.S. Five states (Colorado, New Mexico, Wyoming, Alabama, and Utah) account for 86.2 percent of the U.S. coalbed methane proved reserves. ***Colorado ranks first in the nation for coalbed methane proved reserves with 34 percent of the U.S. total.*** Colorado reported 6.8 Tcf in coalbed methane reserves in 2005, up 17.2 percent from the 5.8 Tcf reported in 2004. This is a new record high since separate reporting for coalbed methane reserves was instituted in 1990.

U.S. coalbed methane production increased 0.7 percent in 2005 to 1,732 Bcf and accounted for 9.4 percent of the U.S. dry gas production (Energy Information Administration, 2006). Colorado coalbed methane production was 487 Bcf in 2005, representing a 2.9 percent decrease from the 501 Bcf reported for 2004 (Colorado Oil and Gas Conservation Commission, 2007). Colorado and New Mexico produced comparable coalbed methane volumes in 2005 (Energy Information Administration, 2006).

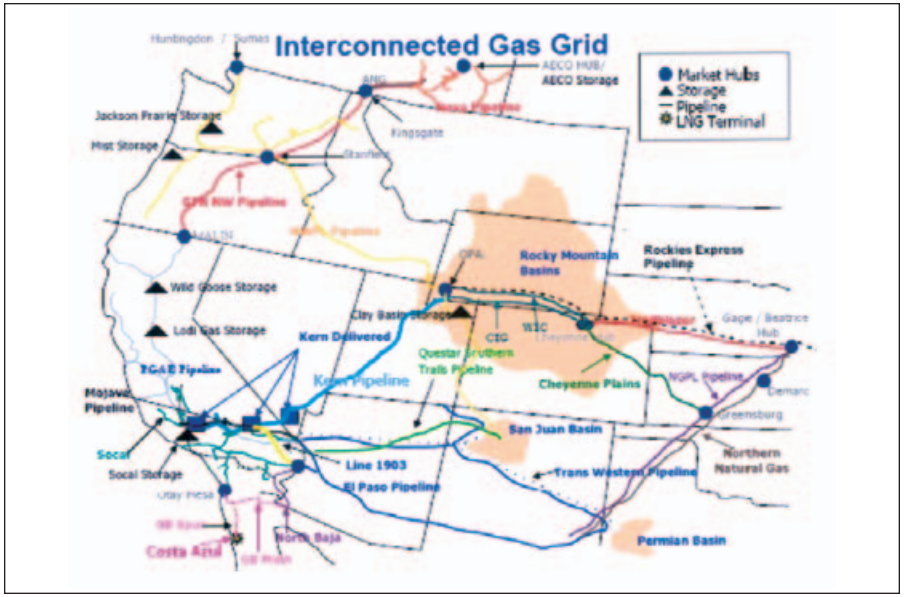

Figure 27. Interconnected pipeline grid for transporting natural gas out of Colorado and the Rocky Mountain basins (from Harpole, 2007). Northwest Pipeline, NWPL; Colorado Interstate Gas, CIG.

ROCKIES PIPELINE CAPACITY

As the growth in natural gas supply shifts to new sources, the Rocky Mountains are emerging as one of the nation's key regions. The Rockies exported 6.3 Bcf per day of natural gas in 2004, and are forecast to increase pipeline exports to 9.3 Bcf per day by 2009 and 10.7 by 2014 (data compiled from El Paso Corporation by Harpole, 2007). If realized, this export capacity would represent an unprecedented 70 percent growth in a decade. The limiting factor in exporting natural gas from Colorado as well as other Rocky Mountain basins is the lack of sufficient pipeline capacity (fig. 27).

Colorado's current natural gas transportation system consists of the Northwest Pipeline System, El Paso Natural Gas Pipeline, and the Colorado Interstate Gas Pipeline System. The Northwest Pipeline System is a 4,000-mile, bi-directional transmission system that crosses through western Colorado and provides access to western Canada, U.S. Rocky Mountains, and San Juan Basin gas supplies. More than 17,000 miles of El Paso Natural Gas pipeline connects gas supplies from Colorado's portion of the San Juan Basin to markets in California. The Colorado Interstate Gas pipeline system extends from producing areas in the Rocky Mountains and Anadarko Basin to the Colorado Front Range with multiple interconnects serving the Midwest, the Southwest, California, and the Pacific Northwest.

Placed in service in May 2003, the Kern River Pipeline is a 1,680-mile pipeline system transporting natural gas out of the Rockies to markets in southern California. However, with a design capacity of 1.7 Bcf per day, Kern River is nearly at capacity (Harpole, 2007). Colorado pipelines transporting natural gas volumes to the west via Northwest Pipeline and Kern River and south via Northwest Pipeline and TransColorado are each nearly at capacity. Alternatively, pipelines that transport natural gas east out of Colorado have available capacity. These pipelines include Cheyenne Plains, Trailblazer, Kinder Morgan Interstate Gas Transmission, and Southern Star Central. However, the take away capacity once this exported volume reaches the Midwest is not available for transporting gas east of the Chicago area.

To link production from Colorado and other Rocky Mountain producing states with Midwestern and northeastern U.S. markets, Kinder Morgan Energy Partners L.P. and Sempra Pipelines & Storage (Partners) are jointly pursuing the development of a new natural gas pipeline that would link producing areas in the Rocky Mountain region to the upper Midwest and eastern U.S. (fig. 28). This pipeline, named the Rockies Express, will be constructed with 42-inch diameter or larger pipe, sufficient compression and supporting facilities to provide transportation capacity of up to 2 Bcf per day. As part of this pipeline project, the Partners have entered into an agreement with Entrega Gas Pipeline Inc., an affiliate of EnCana Corporation, to purchase the Entrega pipeline system for the purpose of consolidating it with the Rockies Express (fig. 28).

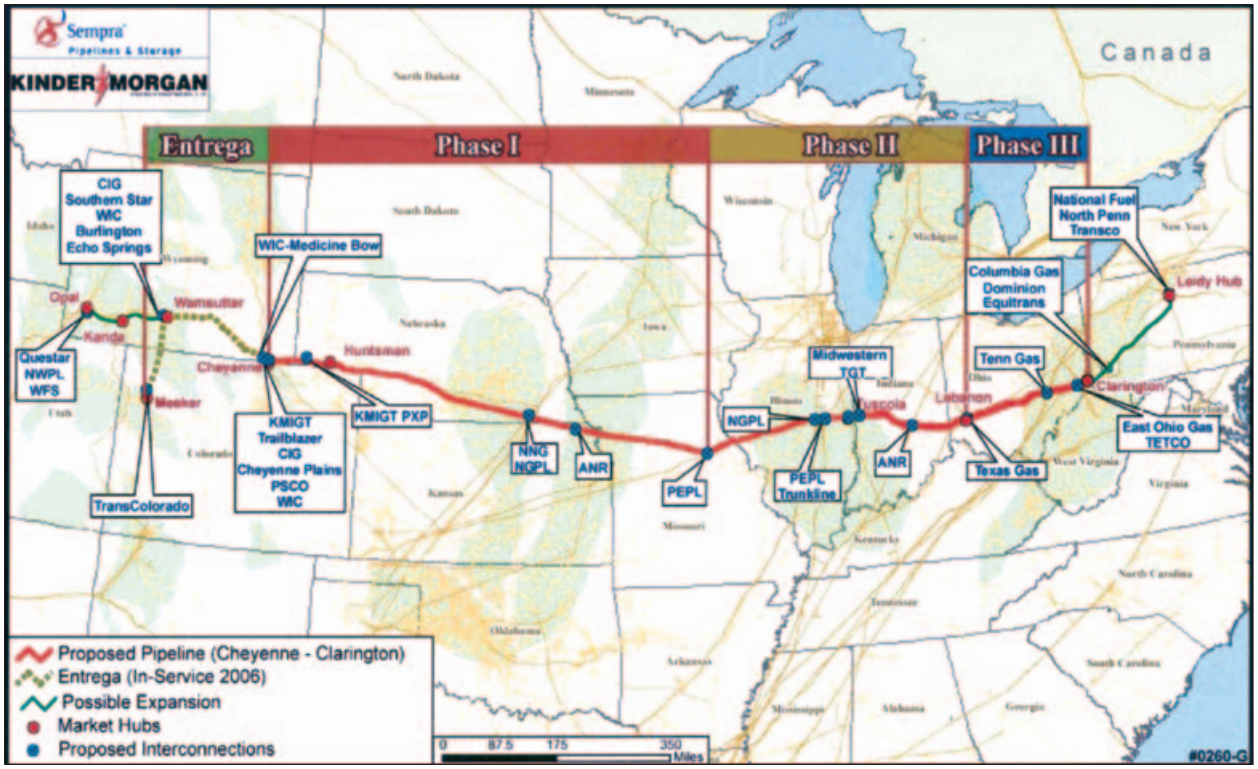

Figure 28. Proposed route and development phases for the Rockies Express pipeline system (from Harpole, 2007).

All three phases of construction will be complete and the pipeline fully operational by June 30, 2009, linking Rocky Mountain supply areas in western Wyoming to Clarington, Ohio. To meet this in-service target date, the Partners are seeking authorization (through multiple filings) from the Federal Energy Regulatory Commission to expand Entrega westward and to construct Rockies Express eastward from the Cheyenne Hub, located in Weld County, Colorado. The Entrega expansion is intended to extend the Entrega pipeline westward to the Opal Hub, located in Lincoln County, Wyoming.

VOLUME, VALUE, AND PRICES FOR 2007

Natural gas production volumes reported for 2006 are expected to increase an average of 6 to 7 percent over the next year or two due to the continuation of aggressive drilling programs throughout the state. If gas prices remain stable at or above the average 2006 price of $6.14 per million cubic feet, the value of that production should increase by as much as 10 percent or more in 2007. Estimated production value for crude oil and natural gas in 2006 is $8.58 billion; this value is forecasted to reach $9.44 billion for 2007 (table 5). The two key components in the growth of Colorado's oil and gas production value for 2007 will be the continuation of strong oil prices and increasing natural gas production. Gas prices for 2007 are expected to remain volatile due to pipeline capacity issues and uncertainties in the emerging LNG (liquefied natural gas) market.

Table 5. Oil and gas production value forecasted for 2007.

Year	Oil and Gas Production Value[1], Billion $	Annual Growth, %
2000	3.35	79
2001	3.59	7
2002	2.68	-25
2003	5.15	92
2004	6.73	31
2005	9.33	39
2006 *Estimated*	8.58	-9
2007 *Forecasted*	9.44	10

[1] CO_2 value is not included

CONVENTIONAL ENERGY RESOURCES: COAL

INTRODUCTION

Coal is our most abundant fossil fuel. In Colorado we are blessed with an abundant supply of "clean coal." Over the last five years coal mines in Colorado have produced more coal than at any time in the State's history. Coal is used mostly for electricity generation; it accounts for nearly 49 percent of our electric fuel supply nationally, 70 percent in Colorado.

The Colorado coal industry had its fourth best production year in 2006 as the 10 active coal mines produced a combined 35,490,337 short tons of coal. Employment and sales increased due to rising demand for electrical "steam" coal. Yet in terms of overall production, the industry has dropped 11 percent since the record high of nearly 40 million tons in 2004. Although this sounds like a bad trend, it is only a temporary setback because at the end of 2006 the 10 active mines were fully operating. Colorado still ranks seventh in coal production nationally. As of March 17, 2007, Colorado coal production is already more than 40 percent ahead (year to date) of production for the same time in 2006.

The number of coal miners employed increased to 2,060, the highest employment since 1988 (fig. 29). The industry is providing many high-paying jobs to rural Colorado. According to Stuart Sanderson of the Colorado Mining Association, "Colorado is home to a viable, safe, and environmentally responsible coal industry that produces nearly $1 billion annually in direct sales." The average federal mineral lease rate per ton ranged from $25.60 to $27.44 in 2006. Discounting spot price sales (up to $42 per ton), the estimated value of Colorado coal produced in 2006 was $974 million. The spot price according to the Department of Energy's Energy Information Administration (EIA) for Uinta Basin coal is $36 per ton (Colorado's Uinta Basin coal is similarly characterized as 11,700 British Thermal Units (Btu) and 0.8 percent sulfur dioxide).

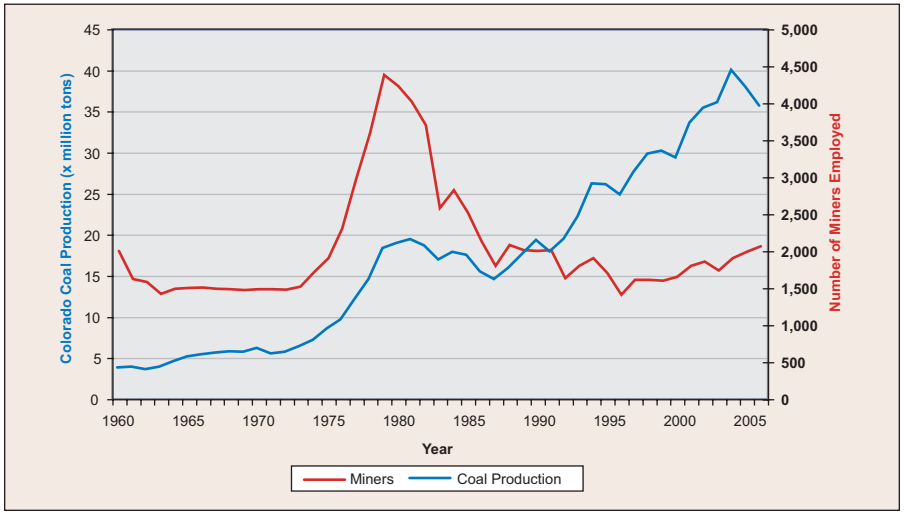

Figure 29. Coal production and employment of miners in Colorado, 1960–2006 (Colorado Division of Reclamation, Mining, and Safety).

Colorado's coal industry has had a significant impact on both local and state economies. In 2006, the 10 active coal mines paid $23.8 million in federal mineral lease royalties (table 6). This is 16.5 percent of the total receipts paid by all extractive industries in 2006. Over half of the $144 million total of Colorado's share of Federal coal royalties was paid to the State school fund and local school districts.

Table 6. Distribution of federal mineral coal lease receipts to the State of Colorado, 2002–2006. Value in million dollars. (Colorado Department of Local Affairs).

Year	2002	2003	2004	2005	2006
Total Receipts from Coal	$16.459	$11.039	$20.643	$18.223	$23.774

Although slow early in the year, Colorado coal mines produced an average of 3 million tons per month after March 2006. Of the total 35.5 million tons produced in 2006, 26.6 million tons came from seven underground mines, while 8.9 million tons came from three surface mines (see fig. 30 for mine locations; tables 7 and 8 for mine statistics). Most of the coal mined in Colorado is bituminous (approximately 79 percent of the state's production); only two mines produced sub-bituminous coal (Trapper and Colowyo mines).

Four Colorado mines set new monthly and/or yearly records in 2006 (table 7). The Bowie #3 Mine set its annual coal production record in 2006 by producing 4.42 million tons. Rio Tinto's Colowyo Mine in Moffat County set its all-time monthly coal production record in March 2006 by producing 594,275 tons. Oxbow Minerals' Elk Creek Mine in Somerset also set a monthly production record in April 2006 by producing 724,629 tons. King Coal in La Plata County also set an all-time monthly coal production record with 50,085 tons produced in September 2006, and a new annual production record with 487,808 tons. King Coal has been mining continuously for over 71 years and has increased production substantially in the last three years. Twentymile Coal's Foidel Creek Mine ranks as the fourth largest producing underground coal mine in the nation.

Table 7. Colorado coal mine statistics, 2006. See Figure 30 for mine locations. (Colorado Division of Reclamation, Mining, and Safety).

County	Parent Company	Operator	Mine Names	Coal Region	Coal Field	Twp., Rng.	Geologic Formation	Producing Bed Names	Seam Thickness	BTU Avg. Shipped	Mine Type	Mining Method	2006 Prod. (tons)	Dec 2006 Miners	Shipment Method
Delta	Colorado Energy Investments, LLC; Sentient Coal Resources, LLC	Bowie Resources Ltd.	Bowie #3	Uinta	Somerset	13S, 91W	Mesaverde	B	12–20 ft	11,650	U	Longwall, continuous	4,420,073	265	Rail
Gunnison	Oxbow Carbon and Minerals Holdings, Inc.	Oxbow Mining, LLC	Elk Creek	Uinta	Somerset	13S, 90W	Mesaverde	D2	D=6–19 ft. D2 seam minable is 14 ft.	12,375	U	Longwall, continuous	5,128,390	291	Rail
Gunnison	Arch Coal Inc.	Mountain Coal Company, Inc.	West Elk	Uinta	Somerset	13S, 90W	Mesaverde	E	12 ft	11,650	U	Longwall, continuous	6,039,936	371	Rail
La Plata	Alpha Natural Resources	National King Coal, LLC	King Coal	San Juan River	Durango	35N, 11W	Upper Menefee	Upper Bed	52–72 in.	12,800	U	Continuous	487,807	74	Truck
Garfield	Rhino Energy, Llc	McClane Canyon Mining, LLC	McClane Canyon	Uinta	Book Cliffs	7S, 102W	Mesaverde	Upper Cameo, Lower Cameo	Upper Cameo= 5–9 ft; Lower Cameo= 8–10 ft	10,475	U	Continuous	266,561	22	Truck
Moffat	Rio Tinto	Colowyo Coal Company, L.P.	Colowyo	Uinta	Danforth Hills	4N, 93W	Williams Fork-Fairfield Coal Group	A–F,X,Y	52.2 ft total; Y=4 ft, X=10.7 ft, A=2 ft, B=6.8 ft, C=6.4 ft, D=10.1 ft, E=6.8 ft, F=5.4 ft	10,453	S	Dragline, Shovels, Dozers	6,342,058	262	Rail
Moffat	PacifiCorp/Tri-State G&T/Salt River	Trapper Mining, Inc.	Trapper	Green River	Yampa	6N, 90W	Williams Fork–Upper Coal Group	H, I, K, L, M, Q	H=6 ft, I=5 ft, K=4 ft, L=4 ft, M=6 ft, Q=10 ft	9,850	S	Dragline, Shovels, Hyd. Excav.	2,080,372	145	Truck
Montrose	Tri-State G&T Assoc.	Western Fuels Colorado, LLC	New Horizon	San Juan River	Nucla-Naturita	46N, 15W	Dakota	1, 2	Kd Upper= 0.80–1.5 ft; Kd Lower= 5.0–7.5 ft	11,680	S	Shovels, dozers	405,611	24	Truck
Rio Blanco	Deseret Generation & Transmission	Blue Mountain Energy, Inc.	Deserado	Uinta	Lower White River	3N, 101W	Williams Fork	B Seam	B= 7–16 ft., D= 6–8 ft.	10,000	U	Longwall, continuous	1,712,553	129	Rail
Routt	Peabody Energy	Twentymile Coal Co.	Twentymile (Foidel Creek)	Green River	Yampa	5N, 86W	Williams Fork-Middle Coal Group	Wadge	8.5–9.5 ft	11,250	U	Longwall, continuous	8,549,845	482	Rail, Truck
Routt	Peabody Energy	Seneca Coal Co.	Seneca II–W/Yoast (closed 2006)	Green River	Yampa	5N,87W	Williams Fork–Middle Coal Group	Wadge, Wolf Cr., Sage Cr.	Wadge= 8.9–12.2 ft (avg. 11.7 ft); Wolf Creek= avg. 20.4 ft; Sage Creek= 3.4–5.4 ft (avg. 4.6 ft)	11,908–12,581	S	Dragline, loaders	57,131	0	Truck
Shaded items indicate new annual production record.							**Mine Type abbreviations: U—underground mine, S—surface mine**					**Totals**	**35,490,337**	**2,065**	

Table 8. Colorado coal production by county, type of production, and employment as of December 2006. All coal production in short tons. Note that Oxbow's Elk Creek Mine operates in both Delta and Gunnison counties. (Division of Reclamation, Mining, and Safety).

County	2006 Production Total	Underground Production	Surface Production	Miners Employed	Surface/ Underground
DELTA	9,241,002	9,241,002		411	0/2
GARFIELD	266,561	266,561		22	0/1
GUNNISON	6,347,397	6,347,397		517	0/2
LA PLATA	487,808	487,808		74	0/1
MOFFAT	8,422,429		8,422,429	407	2/0
MONTROSE	405,611		405,611	24	1/0
RIO BLANCO	1,712,553	1,712,553		129	0/1
ROUTT	8,606,976	8,606,976	57,131	482	2/1
TOTALS	**35,490,337**	**26,605,166**	**8,885,171**	**2,065**	**4/8**

Coal was produced in eight Colorado counties in 2006. For the first time, Delta County was the state's top coal producing county (table 8), with over 9.2 million tons, all from underground mining. This is attributed to Oxbow Mining's Elk Creek Mine, which produced mostly in Gunnison County in 2004 and 2005, and now mostly produces in Delta County. Routt and Moffat counties were second and third, respectively. A small amount (57,131 short tons) of coal production was attributed to the Seneca Mines in Routt County in January and February 2006, after the mine closed in December, 2005.

Over 1,740 Colorado coal mines have produced 1.3 billion tons of coal since 1864 (fig. 31). Most of the historic coal has been produced in the Uinta Coal Region (36.1 percent), and the Green River Coal Region (26.7 percent), which are both actively mined today. In terms of depletion, 2.24 billion tons of coal have been mined or sterilized in Colorado through December 31, 2006 (using an average recovery factor of 58 percent). In 2006, over 23.9 million tons of coals were mined in the Uinta Coal Region from six mines.

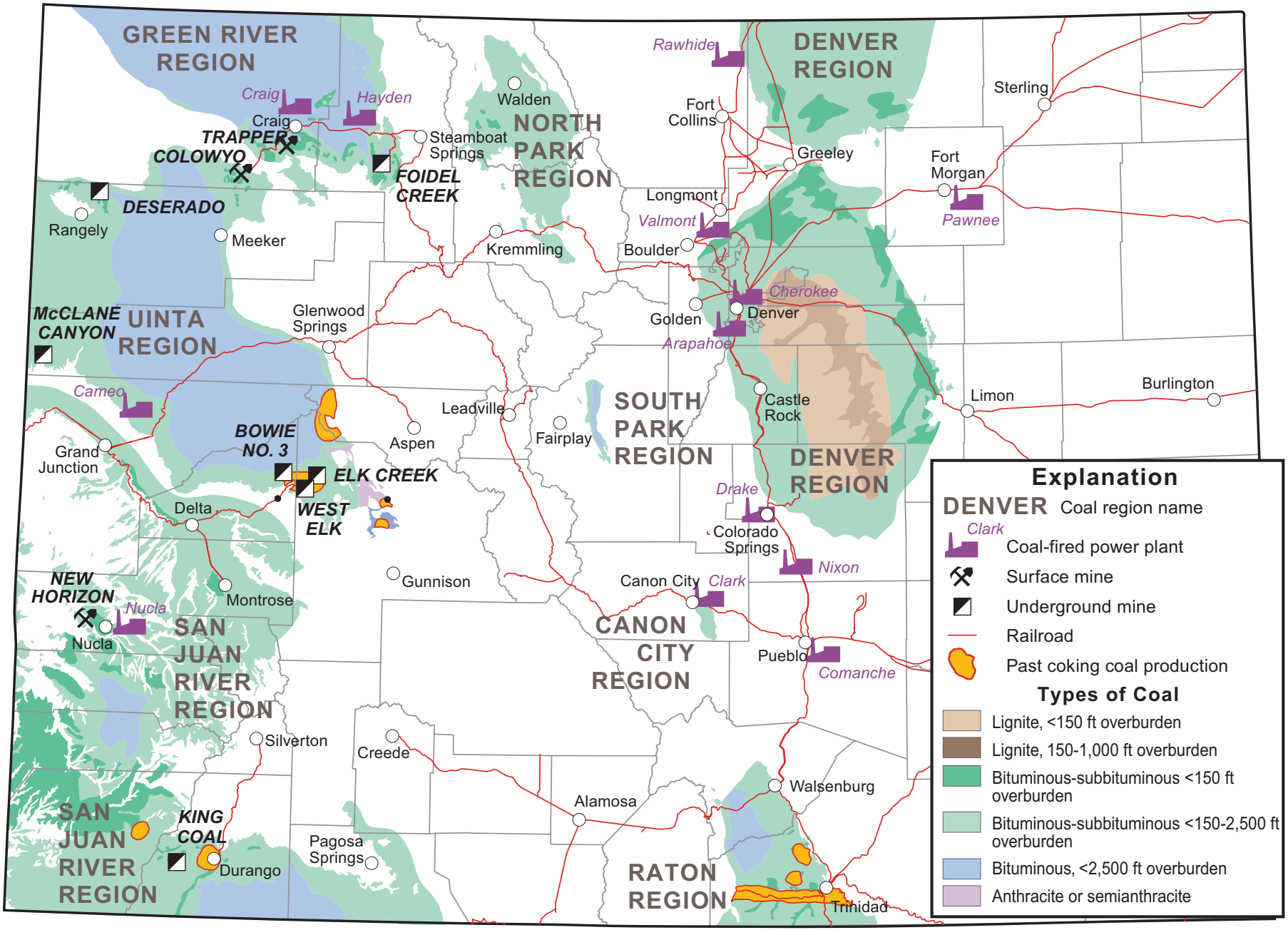

Figure 30. Locations of coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2006.

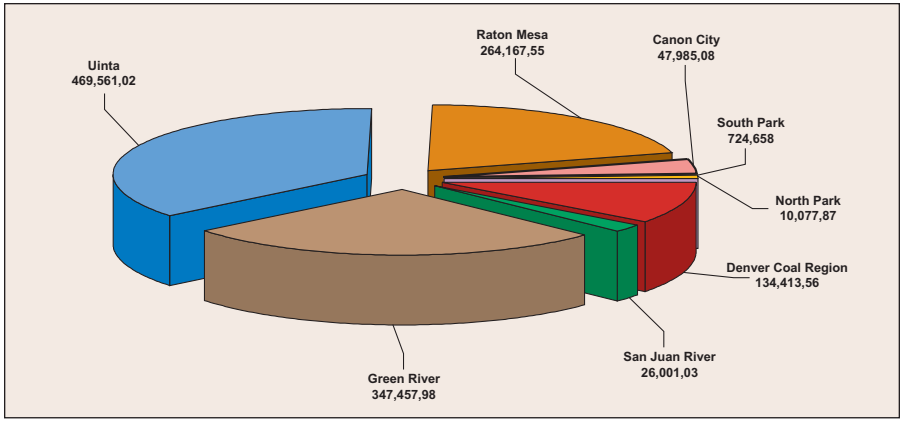

Figure 31. Historic Colorado coal production in percent by coal regions. Total coal production for Colorado as of January 1, 2007 is 1.3 billion tons.

EXPLORATION

With the prices of coal remaining at a stable but relatively high level, coal exploration was active. Rule 2.02 of the Colorado mining statutes requires any person intending to conduct coal exploration to remove more than 250 tons to file a notice of intent to explore with the Colorado Division of Reclamation, Mining, and Safety (DRMS), formerly the Division of Minerals and Geology. Most coal mines have been expanding their lease holdings by drilling in new development areas. Nine exploration permits were filed in 2006 with the DRMS. Of the active mines in west-central Colorado, Central Appalachian Mining (now Rhino Energy, McClane Canyon Mine) drilled for geotechnical information, Mountain Coal (West Elk Mine) drilled the Deer Creek shaft exploration project, and Bowie Resources conducted the Terror Creek 2-D seismic survey. Oxbow Mining (Elk Creek Mine) filed for a new license to explore the North Elk Creek area.

In northwest Colorado, Juniper Coal Company, a subsidiary of Peabody Energy, continued exploration at the Big Elk property south of Hayden. Peabody Energy, the nation's largest coal producing company, owns coal reserves south of Hayden (Big Elk lease area) and near Craig (Empire Mines), which will help supply the Hayden Power Plant after Twentymile Mine is depleted years from now. Colowyo Mine geologists finished their reserve definition drilling program in the South Taylor and Collom lease area.

Reclamation and re-activation work at the New Elk Mine (formerly the Allen Mine) in the Raton Basin continue in early 2007 (fig. 32). The New Elk Coal Company owns the property and is currently de-watering the old mine workings in an attempt to re-open the remaining economic parts of the mine. They want to extract additional reserves from the Allen, Apache, or Maxwell seams in the Raton Formation.

Figure 32. Coal mining activities resuming at the New Elk (formerly Allen Mine) in 2007.

The Lorencito Canyon Mine in the Raton Basin has been in reclamation status since its closure in 2002. The surface property is owned by several large landowners and operators who opened discussions in 2006 with DRMS about re-opening the mine, but officially no new applications have been submitted. The high-Btu coal and coking coal of the Raton Mesa Coal Region is a valuable market commodity that is undervalued in today's steam coal marketplace.

Exploration and drilling are planned with several permit revisions at existing mines for 2007. DRMS data show that Twentymile Coal is adding 320 acres to their existing lease and enlarging the affected area within their permit boundary. Colowyo has submitted a permit revision to DRMS for the South Taylor Creek and Lower Wilson Creek areas. If granted, this would add 6,050 new permit acres to the existing area. King Coal in La Plata County is expanding their existing area by 720 acres, of which 315 are approved for underground mining. A new portal will be put in two miles west of the existing mine area as the new King II Mine. They will mine the upper Menefee coal beds, the same beds as the existing mine. The bed thickness is 8–10 feet. Bowie Resources requested a permit revision for adding 592 acres at their property as the northern extension of the B-seam mine plan. Arch Coal's Arc-Land Company has applied for a notice of intent to explore in the Book Cliffs region at Township 7–8 South, Range 101–102 West.

A conditional-use permit was approved in late February 2007 by the Fremont County commissioners for the proposed new Northfield coal mine. This underground mine will be located south of Florence near the old Energy Fuels' Southfield

Mine. The mine is proposed to be between 300 and 800 feet deep in a four- to six-foot-thick coal bed. Northfield Partners, LLC will have to get state approval and permits from DRMS to explore the Northfield site. The mine will extract coal from the Ocean Wave Seam of the Vermejo Formation.

DISTRIBUTION

The main transportation method for coal in the West is by rail. Both the Union Pacific (UP) and the Burlington Northern/Santa Fe (BNSF) railroads transport coal through Colorado. The UP moves most of the coal out of western Colorado through the Moffat Tunnel to customers in the Midwest. BNSF transports Wyoming coal to the Rawhide Power Plant (fig. 33) north of Ft. Collins, and to power plants along the Front Range, and through Denver, Colorado Springs, and Pueblo to customers in Texas and the southeast U.S.

More than 77 percent of all rail shipments originating in Colorado are coal products. Over 51 percent of the rail shipments terminating in Colorado are coal, by far the single most important rail commodity in the state. Coal rail freight growth is expected to increase nationally and the Colorado railroad infrastructure, while currently supplying mines that are under producing, is inadequate for future growth. Costs to build a twin Moffat Tunnel are at least $500 million, an investment that the railroads can only undertake with partnerships.

Figure 33. Conveyor belts at the Rawhide Power Plant north of Wellington, Larimer County.

The constraint in the existing rail infrastructure in Colorado is a limiting factor for coal production in the state. In 2006, over 15.5 million tons of coal moved from the Somerset Coal Field to the Front Range and further east. Stockpiles at the three North Fork mines decreased because of slowdowns at the mines, but in early 2007 stockpiles began increasing again. This is directly related to the number of coal trains that can move in and out of the one-way valley on the UP Railway. In 2006, over 28 million tons of coal were transported through the Moffat Tunnel between Winter Park and Denver.

Table 9. Distribution of coal produced in Colorado to electric utilities, industrial plants, and residential customers by state, 2005. (Energy Information Administration).

State of Destination	Electric Utilities	Industrial Plants	Residential/ Commercial	Total	Percentage of Total Distribution	Change from 2004	Transportation
Alabama	823	—	—	823		Increase	Rail
Arizona	1,127	140	—	1,267		Increase	Rail, Truck
Arkansas	226	206	—	432		Increase	Rail
California	—	106	17	123		Decrease	Rail
Colorado (in-state)	11,473	306	131	11,910	32.7%	Increase	Rail, truck
Florida	321	—	—	321		Increase	Rail
Georgia	479		—	479		Increase	Rail
Illinois	451	6	—	457		Decrease	Rail
Iowa	115	183	—	298		Decrease	Rail
Kansas	—	62	—	62		Decrease	Rail
Kentucky	3,546	—	—	3,546		Decrease	Rail, River
Maryland	20	—	—	20		Decrease	Rail
Massachusetts	582	—	—	582		Decrease	Tidewater piers, Rail
Michigan	436	252	—	688		Increase	Rail, Great Lakes, River, Truck
Minnesota		47		47		New	Rail
Mississippi	1,711	—	—	1,711		Decrease	Rail
Missouri	45	54	—	99		Decrease	Rail
Nebraska	—	140	4	144		Increase	Rail
Nevada	332	—	—	332		Increase	Rail
New Jersey	367	—	—	367		Increase	Rail
New Mexico	—	79	1	80		Decrease	Truck
Ohio	597	—	—	597		Increase	Rail, River
Oklahoma	—	115	—	115		Increase	Rail
Tennessee	4,135	—	—	4,135		Increase	Rail
Texas	1,740	1,466	—	3,206		Decrease	Rail, truck
Utah	2,142	—	—	2,142		Decrease	Rail
Virginia	147			147		New	Rail
Wisconsin	1,321	190	—	1,511		Decrease	Rail, Great Lakes, Truck
Wyoming	—	118	—	118		Decrease	Truck
Domestic distribution to other states	**20,663**	**3,164**	**22**	**23,849**	**65.4%**	**up**	
Total Domestic (including Colorado)	**32,136**	**3,470**	**153**	**35,759**	**98.1%**	**up**	
Foreign Exports to Mexico	**—**	**706**	**0**	**706**	**1.9%**	**up**	
Total Domestic (including Colo) and Foreign Export	**32,136**	**4,176**	**153**	**36,465**	**100.0%**	**up**	

All figures in thousands of short tons. Note: EIA total reflects coal transportation inventories, 2005. Represents most current published data.

Coal distribution data is tabulated by the EIA but is typically one year behind; the most updated information is for 2005. Over two-thirds of the coal produced in Colorado is shipped by rail to 28 other states (table 9), and is sold as far away as Massachusetts and Florida. Most of Colorado's produced coal is shipped to states east of us where it is blended with high-sulfur Eastern coals to reduce pollution at minimally-compliant power plants. The leading Colorado coal exports to other states (2005 data) were to Tennessee, Kentucky, Texas, Utah, Mississippi, and Wisconsin. In addition to coal shipped for use in power plants, over 3.1 million tons of coal are shipped to industrial plants in Texas, Michigan, Arkansas, and Iowa for cement manufacturing and other industrial uses. Of the Colorado coal consumers in the Western U.S., electric utilities and industrial plants in Arizona, Nevada, and New Mexico accounted for about 2 million tons in coal sales. Around 2 million tons per year are shipped to Utah's Bonanza Power Plant via the 34-mile private railway from the Deserado Mine.

CONSUMPTION

Coal is consumed at coal-fired power plants, commercial industries, and manufacturing plants throughout the state. Power plants use the coal to generate steam to power generators to create electricity. A few blacksmiths use coal in Colorado as well. In Loma, Mesa County, a local blacksmith imports coal from Pennsylvania.

Manufacturing sites include nonmetallic mineral products companies and primary metal manufacturing companies that use coal for various purposes. According to EIA, a total of 19.445 million tons of coal were consumed in Colorado in 2005 (table 10). This is down 1.6 percent over 2004. Of this total, 19.013 million tons were consumed at power plants, which is 97.8 percent of Colorado's total coal consumption.

Table 10. Colorado coal consumption by type of sector 2004–2005. W = withheld to avoid disclosure of individual company data. (Energy Information Administration, 2007, most recent data).

2004 (million tons)				2005 (million tons)				
Electric Power	Other Industrial	Residential and Commercial	2004 Total	Electric Power	Other Industrial	Residential and Commercial	2005 Total	% Change
19,251	W	W	19,766	19,013	W	W	19,445	-1.6

Xcel Energy owns or operates seven coal-fired power plants in Colorado and is the largest consumer of coal in the state. The Craig Power Station in Moffat County consumed nearly 5 million tons of coal in 2006, generating over 10.7 million Megawatt-hours (Mw-h) of electricity. The Craig Station receives coal shipments from two Moffat County mines, Trapper and Colowyo mines.

Figure 34. Construction at the new generating facility at Xcel Energy's Comanche Power Station in Pueblo County, March 2007. The new stack is located on the right.

Xcel has also begun construction on its new coal-fired power plant in Pueblo (fig. 34). This is a super-critical pulverized unit that will be added to the existing Comanche Station. Super-critical pulverized coal units are preferred because in the absence of a carbon tax the cost of generating electricity from pulverized coal is cheaper than from IGCC plants. This near-term opportunity for higher efficiency was chosen over a 'capture ready' type of plant. It will add 750 Megawatts (Mw) of capacity to the plant. Coal will be supplied from Wyoming's Powder River Basin.

Over 37.5 million Mw-h of gross power are generated by Colorado coal-fired plants annually (table 11). Gross electric generation is the product of megawatts of power generated times the number of hours in a year (8,760). Some of these plants also use natural gas or fuel oil as additional power sources.

In 2006, Westminster-based Tri-State Generation and Transmission announced plans to spend $5 billion building three new coal-fired power plants in the Rocky Mountain Region. One plant would be located in southeast Colorado near Lamar, and two others nearby in the Holcomb, Kansas area to serve their growing Colorado customer base. Tri-State favors conventional coal plant construction because coal-gasification technology is unproven at high altitudes with the current technology. The three new coal plants represent a "backstop" plan that may be modified in the future if renewable or energy efficient technology prove feasible. Along

Table 11. Electric generation and fuel consumption at coal-fired power plants in Colorado, 2006. Refer to Figure 30 for locations on map. PRB = Powder River Basin, Wyoming. Mw = Megawatts, Mcf = Thousand cubic feet, Bbls = Barrels (Source: Data from utility company annual reports).

Power Plant	Utility	Nameplate Rating (Mw)	2005 Gross Electric Generation (Mw-h)	2006 Gross Electric Generation (Mw-h)	2006 Fuel Consumption			Origin of Coal
					Coal (tons)	Gas (Mcf)	Fuel Oil (Bbls)	
W.N. Clark	Aquila Inc.	38	306,928	279,693	152,946	0	0	86% Foidel Creek, 14% West Elk
Martin Drake	Colorado Springs Utilities	273	1,205,734	1,964,478	912,302	152,105	0	79% Foidel Creek, 21% Wyoming PRB
Nixon	Colorado Springs Utilities	225	1,628,027	1,737,182	975,946	0	2,981	Wyoming PRB
Rawhide	Platte River Power Auth.	270	2,121,749	2,159,230	1,241,051	653,729	2,490	Wyoming PRB
Craig	Tri-State G & T Assn.	1264	10,855,000	10,764,000	4,985,000	62,657	993	58% Colowyo, 42% Trapper
Nucla	Tri-State G & T Assn.	100	825,699	825,326	404,899	0	0	New Horizon
Arapahoe	Xcel Energy	144	971,901	958,440	664,125	32,140	0	Wyoming PRB
Cameo	Xcel Energy	66	531,942	378,614	238,563	31,856	0	McClane Canyon
Cherokee	Xcel Energy	710	5,457,818	4,782,833	2,267,449	582,450	0	99 % Foidel Creek, 1% Colowyo
Comanche	Xcel Energy	700	4,709,267	4,877,932	2,955,209	72,466	0	Wyoming PRB
Pawnee	Xcel Energy	547	3,139,143	3,765,345	2,339,183	129,802	0	Wyoming PRB
Valmont	Xcel Energy	166	1,588,084	1,266,696	529,762	48,729	0	73% Foidel Creek, 26% Colowyo, 1% Elk Creek
Hayden	Xcel Energy/Pacifcorp/Salt River Project	447	3,973,253	3,805,345	1,706,014	32,890	1,243	Foidel Creek
State Totals		**—**	**37,314,545**	**37,565,114**	**19,372,449**	**1,798,824**	**7,707**	**—**

with construction of the three plants 1,000 miles of transmission line to carry high voltage power into Colorado will be constructed. The $1 billion transmission network would tentatively start in 2009 and be finished by 2012, when the first Kansas generator is completed.

Tri-State's Nucla Station produced 100 megawatts of generating capacity. It is the first atmospheric circulating fluidized-bed combustion power plant in the world. It captures more than 70 percent of the sulfur dioxide emissions. The fabric-filter bag house collects more than 90 percent of all particulate matter.

Coal consumption in Colorado is mostly for electric generation, but about two percent is consumed in the manufacturing and commercial sectors. Major manufacturers using coal for boilers in Colorado include Cemex, Inc. and Holcim, Inc. for cement-manufacturing; TXI, Inc. for lightweight shale aggregates; Western Sugar for their sugar beet refining; and the Coors Brewery. Some of this coal is from Colorado but some is from Wyoming and Pennsylvania. There is no coking coal market in Colorado today, nor is any Colorado coal used at coke plants in the eastern U.S. Colorado has over 2 billion tons of coking coal resources in the Trinidad and Somerset coal fields, but none were produced for that purpose in 2006.

Black Hills Corporation, a Colorado-based company, is partially acquiring Aquila Corporation's utility operations and properties in Colorado, Kansas, Nebraska, and Iowa in early 2007. This will broaden Black Hills' regional presence and retail utility base. The W.N. Clark coal-fired power plant in Canon City will now be owned by Great Plains Energy, the parent company of Black Hills Corp.

EMPLOYMENT, PRODUCTIVITY, AND SAFETY

Based on the DRMS monthly listing of coal mining data, the nine percent increase in employment from December 2005 to December 2006 indicates a growing demand for coal miners in western Colorado. The number of employees at Colorado coal mines is over 2,200, of which 1,991 are miners. Coal is the biggest component of Colorado's mining industry today. This increase in employment comes despite the closing of two mines (Seneca Mines) in 2005 and coal production decline in 2006. This indicates that the remaining active mines have hired many new personnel or miners from Seneca. With the closing of the Seneca Mines, the number of non-union miners has increased over union miners in Colorado.

Colorado's coal miners produce more coal per man-hour than most other states. Coal mining productivity is defined as the total state coal production divided by the total direct labor hours worked by all mine employees. In 2005 (again the most recent data available from EIA), the average production per employee per miner-hour was 8.52 tons, down 6.4 percent from 2004, and much higher than the U.S. average of 6.36 tons per miner-hour. Underground miners in Colorado (both continuous and longwall) produced at a rate of 8.65 tons per miner-hour, down from the previous year. This is the second highest rate in the nation after underground miners in New Mexico.

In terms of worker safety, 2006 was the sixth year in a row without a coal mining fatality in Colorado. However, the same cannot be said for the U.S. coal industry. In 2006, 47 miners were killed nationally in the worst coal mining year in terms of fatalities in 10 years. This reversed a trend where new and improved mining equipment and mining techniques has improved coal mine safety dramatically.

On June 15, 2006, President Bush signed the Mine Improvement and New Emergency Response Act of 2006. This new legislation is the most significant safety improvement in 30 years. It requires underground operators to improve accident preparedness in terms of response plans. The Act calls for two rescue teams to be located within one hour of every mine, promotes use of new equipment and technology that is currently commercially available, requires emergency response within 15 minutes, and gives the Mine Safety and Health Administration new authority over fine assessment, and establishes a new scholarship program for miners.

UNDERGROUND LONGWALL MINING ACTIVITY

The 2006 U.S. Longwall Census reports five active longwall systems operating in Colorado (table 12). Longwall machinery is important to Colorado because of its safety and productivity records. Longwall technology is an important reason why Colorado's coal production from its thick coal beds has doubled since 1982. Nationally, a total of 47 mines operate 53 longwall faces. The average longwall face in Colorado mines is now over 9,000 feet long. The biggest shearer and set of shields is the new Deutsche Bergbau Technik (DBT) longwall at Peabody Energy's Foidel Creek Mine in Routt County. According to *CoalAge*, the EL3000 shearer has 2,970 horsepower and the supports have a yield of 1,328 tons; the shields are the nation's largest at 1,300 tons.

DBT GmbH was purchased by Bucyrus International of South Milwaukee, Wisconsin early in 2007. The $700 million price and stock acquisition will make Bucyrus not only a global leader in large surface mining equipment but also a leader in underground mining technology. Two of the five longwall shearers in Colorado are manufactured by DBT. DBT designs and manufactures longwall mining equipment, as well as room and pillar mining equipment.

Table 12. Longwall statistics from Colorado's underground coal mines in 2006, abbreviations: ft = feet, in=inches. (*CoalAge* magazine, Feb. 2007).

Company Name (Mine)	Seam	Seam ht. (in)	Cutting ht. (in.)	Panel width (ft)	Panel length (ft)	Overburden (ft)	Depth of cut (in)	Shearer/ horsepower
Bowie Resources (Bowie Mine #3)	B	108–120	96–120	845	7,000	1,100	36	DBT EL2000 DDR/1,945
Blue Mountain Energy (Deserado Mine)	B	84–168	132	800	11,000	400–900	32	Joy 4LS-5 DDR/1,030
Oxbow Mining (Elk Creek Mine)	D	108–180	132	805	6,800	500–2,000	30	Joy 7LS-3A DDR/1,720
Peabody Energy (Foidel Creek Mine)	Wadge	108	108	1,000	12,000–15,000	1,400–1,650	39.4	DBT EL3000 DDR/2,970
Arch Coal (West Elk Mine)	B	276	144	950	4,000–7,000	600–1,800	40	Joy 6LS-2 DDR/1,720

COAL QUALITY

Four components are important in determining the desirability of a certain coal: ash, sulfur, and mercury content, as well as the heat value in Btu. These, along with transportation costs, determine the price that can be obtained for a particular coal. The amount of ash determines how much impurities such as clay particles are mixed in with the coal. The lower the ash content, the lower the waste products after burning. The amount of sulfur and mercury determines how much removal treatment is required to comply with Clean-Air standards. The Btu value determines how much heat can be generated from a pound of coal. The average quality of coal mined in Colorado today is 10,952 Btu per pound, 0.6 percent sulfur, and 10.55 percent ash. This is characterized as a high Btu, moderate ash, and low sulfur coal. Colorado is second only to Illinois in bituminous coal reserves, but is by far the leader in bituminous Clean Air compliant coal reserves. According to EIA data, the average quality of coal received at manufacturing plants in Colorado for 2005 was 11,620 Btu, 0.51 percent sulfur, and 9.77 percent ash. Btu of Colorado coal increased from the 11,336 Btu reported for 2005.

Table 13. Average quality values for mineable coal beds from all coal mines in Colorado by coal region. Mercury values are from the U.S. Geological Society National Coal Quality Inventory at active mines in 2001 (Colorado Geological Survey Information Series 58).

Analyses	Denver Region	Green River Region	North Park Region	Raton Mesa Region	San Juan Region	Uinta Region	South Park Region	Cañon City Region
Ash (percent)	11.2	9	12.4	16.1	12.7	6.8	6.4	9.8
Sulfur (percent)	0.3	0.6	0.5	0.7	0.8	0.6	0.5	0.8
Btu (per lb.)	9,072	10,973	9,483	12,541	12,758	11,879	9,780	11,130
Mercury (ppm)	—	<0.02	—	0.035	0.03	0.02	—	0.185

Colorado steam coal is attractive because of its high quality for Clean Air Act compliance with power plant emission standards (table 13). The San Juan and Raton Mesa Coal Regions have the highest heat values, averaging over 12,500 Btu. The Denver Coal Region has the lowest sulfur coal averaging 0.3 percent. The South Park and Uinta Coal Regions have less than seven percent ash. Colorado coal produced in 2006 ranges between 0.4 and 0.8 percent sulfur, which is about two or three times lower than the average eastern bituminous coal. The average quality of coal received at electric utilities in Colorado is compliant with Clean Air Act standards.

RESERVES

Over 70 percent of the global recoverable coal reserves are in the U.S., Russia, China, India, and Australia (the leading coal exporting country). In the U.S., Wyoming is the largest coal-producing state, and has been for 20 years. Over 90 percent of the U.S. coal production goes to electricity generation, supplying about 50 percent of the country's electricity. When adjusted for inflation, the price of U.S. coal in 2005 was less than the price in 1949.

About 75 percent of Colorado coal leases are federally owned. Nearly 50,000 acres are currently under lease. For 2005, EIA reported that Colorado had 382 million tons of recoverable coal reserves under lease at active mines, an eight percent decrease over 2004. The average recovery percentage at Colorado coal mines is 66.88 percent. EIA's Demonstrated Reserve Base (DRB) data show Colorado has 16.223 billion tons of coal (table 14); 11.46 billion tons underground mineable and 4.76 billion tons surface mineable. The estimated recoverable reserves (9.76 billion tons) are defined as that part of the DRB that can be mined using today's mining technology.

Table 14. Colorado recoverable coal reserves, estimated recoverable reserves, and demonstrated reserve base by mining method, 2005 most recent data available. All units in million short tons (Energy Information Administration, 2007).

Underground Mineable Coal			Surface Mineable Coal			Total		
Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base
338	6,015	11,461	44	3,747	4,762	382	9,761	16,223

Northwest Colorado coal mining news

One thing that all of the coal mines in northwest Colorado have in common these days is a lack of experienced personnel. Many older workforce miners have retired and much of the mining work force is young and inexperienced. These new miners do not always last long as the competition for labor in the petroleum industry situated in the Piceance Basin claims many new employees. Hence, the mines are paying extremely good salaries and searching a broader network to get qualified miners to work in northwest Colorado.

Peabody Energy and the Twentymile Coal Company near Oak Creek continued with their record coal production. For the tenth year in a row the Foidel Creek Mine was the state's leading producer of coal. In 2006 they produced 800,000 tons less than their record breaking year of 2005. Major changes to the mine include installation of a new longwall. Twentymile encountered equipment problems during installation of the new longwall. The old longwall equipment lasted 11 years and produced over 93 million tons of coal. Peabody hopes that the new longwall will enable the mine to produce over 10 million tons in 2007. Foidel Creek will now supply the Hayden Station with coal trucked over the Twentymile Road. Other customers for the 11,400 Btu low sulfur coal include power plants in Colorado, Mississippi, Wisconsin, Arizona, and Alabama. Industrial coal mostly for cement manufacturing was shipped to Wyoming, Iowa, Texas, Wisconsin, and Colorado. *CoalAge* Magazine reports that Twentymile was running above pre-installation levels as it ramped up to expand production by October 2006.

At the 109th National Western Mining Conference in Denver during February 2007, the Colorado Mining Association and the Colorado Division of Reclamation, Mining and Safety awarded the 2006 Excellence in Reclamation Award to the Seneca Coal Company. This award recognizes Seneca for reclaiming more than 4,000 acres of surface mined area for wildlife habitat and livestock grazing. Seneca also won this award for best practices for re-establishing native trees for enhanced wildlife habitat.

The Trapper Mine near Craig in Moffat County cut into a large landslide at their G-dip line pit in October 2006. The 260-acre landslide occurred within the permit boundary after a month of heavy rains. Both the G dip-line and G strike-line pits were involved. They are currently installing monitoring devices to determine the slip plane and other hydrologic properties. G and K reserve areas are affected and Trapper personnel hope to augment their mine plan to mine the deeper reserves in the future. The short term mine plan has changed to a two-dragline operation. The future coal production will be from the A–E east pit, with the assistance of the Baby Doe dragline (fig. 35). Then they will use two draglines in F pit, and the third will remain in Z-pit, a strike pit. It will change to dip-line mining near the end of the pit. Trapper personnel are re-evaluating reserves as the market changes by using larger dozers to go deeper in their pits. Surface operations should still be on target to mine at Trapper until 2014.

Rio Tinto Energy America's Colowyo Mine in Moffat County is the state's largest surface coal mine. Colowyo has operated continuously for over 29 years in this location producing 9.62 percent of all the coal produced in Colorado's history. Rio Tinto decided that the South Taylor Pit will be the next surface operation after the current West Pit is exhausted, and hopes to begin setup operations in the South Taylor Pit in 2007 and begin mining coal by 2008. Currently, the three draglines and one shovel operation are moving toward the south end of the West Pit, but coal seams are thinning in that direction. South Taylor Pit would mine six major seams between the B to G coal beds of the Williams Fork Formation. Keith Haley is the new general manager of Colowyo Mine.

Coal production for 2006 at the Deserado Mine in Rio Blanco County near Rangely was down due to stockpile increases at the Bonanza Power Plant. The longwall is now mining the 7-to 16-foot thick B-seam at a depth of over 900 feet. Deserado has lost some employees to the competitive petroleum industry in Rio Blanco County. Deserado is replacing old equipment and in 2006 they installed

Figure 35. Baby Doe Dragline at the Trapper Mine moving from the G dip line pit, October 2006. Landslide ridge in pit floor seen at left.

a new feeder breaker. In-place reserves will keep Deserado mining in its current development plan through 2026. Possible oil shale development will need a large source of electricity in this area if it goes forward. Deserado may be able to supply that industry in the future.

At the 109th National Western Mining Conference David Zatezalo, president of Rhino Energy—McClane Canyon Mining, discussed the new Red Cliff Project, located southeast of the current mine location in Garfield County. Through a corporate restructuring in 2006, Rhino Energy now owns the rights to operate coal mining at McClane Canyon. They announced plans to build a 15-mile rail spur from Mack to the proposed Red Cliff Mine location and expand coal production to about 6 million tons per year. The Red Cliff project will mine the same Cameo coal beds as the McClane Canyon Mine. There is no scheduled timetable for the new mine to open. Currently the mine hauls 300,000 tons of coal annually via truck to the Cameo Power Plant in Palisade, Colorado.

Somerset coal field news

In the North Fork Valley, three active operations are mining coal from the Paonia Shale Member of the Mesaverde Group. On the north side of the valley are the Oxbow Mining Company's Elk Creek Mine and the Bowie Coal Company's Bowie #3 Mine. Elk Creek mines the 14-foot thick D2 seam; Bowie #3 mines the 10–14 foot thick lower split B-seams. The third mine, Arch Coal/Mountain Coal Company's West Elk Mine, is the only mine on the south side of the valley. This mine produces coal from the 10–11-foot thick E-seam. These mines all produce low-sulfur, and high-Btu bituminous coal. All of the coal produced at these mines is hauled by Union Pacific Rail from the valley to Grand Junction and then to various destination points as far away as Florida and Massachusetts. The Tennessee Valley Authority uses North Fork coal from all three mines.

Oxbow Mining Company's Elk Creek Mine became fully operational after March 2006. The longwall is currently mining in both Delta and Gunnison counties, but mostly in Delta County for all of 2007. Elk Creek was able to overcome head-gate troubles on the longwall early in the year and produced over 5 million tons of coal in just nine months time. Head-gate problems stopped them again in early 2007. The current mine is overlying a B-seam that was previously mined out by the old U.S. Steel Somerset Mine.

Oxbow has completed a new warehouse expansion project. They have picked up three new areas in a lease modification to the south and east of the current operation. Elk Creek has enough coal to mine at its existing location until 2017 (projected life-of-mine). They are mining 11 feet of a 10–14 foot D2 coal bed. Most of the coal is shipped to Wisconsin and Arkansas for steam coal. The furthest customer from the mine is Virgina Power north of Boston, Massachusetts. Texas Industries (TXI) uses Elk Creek coal at their cement plants in Texas.

In 2006, Bowie Resources Mine No.3 produced 'washed' coal from the preparation plant with 4.29 million tons shipped (fig. 36). Bowie No.3 (B-seam) accounted for 4.21 million tons, while 210,000 tons came from the Bowie No.2 Mine in the D-seam, which still operates a small conventional miner. In 2006, Bowie Resources shipped coal to utility and manufacturing customers in Arkansas, Colorado, Delaware, Indiana, Kentucky, Michigan, Minnesota, Nevada, Ohio, Texas, and Wisconsin. Within Colorado, Bowie supplies the Colorado State Hospital in Pueblo with a stoker coal product. Bowie No. 3 Mine is mining a 12–14 foot lower B seam, which they will remain in for 2007 as a sill has replaced the upper B seam. The longwall will move back to the upper B seam in 2008. Igneous sills have been found in the upper B seam for a few years now. A new ventilation shaft will be installed later this year in Hubbard Creek.

Arch Coal's West Elk Mine on the east end of the North Fork Valley had an average year. Early in the year, the mine was able to suppress a combustion-related event and restore ventilation and operations. West Elk resumed longwall production in March 2006 to produce over 6 million tons in just 10 months time in 2006. The new general manager is Pete Wycoff. A new shaft was put in 2006.

Figure 36. Conveyor system at the Bowie Resources mine complex in the North Fork Valley.

Southwest Colorado coal mining news

For the third year in a row, National King Coal's 71-year old mine near Durango set a new annual coal production record. Originally opened in 1936, King Coal is Colorado's oldest and longest continually operating coal mine, having produced over 6.1 million tons of coal from the Menefee Formation of the Mesaverde Group. The high Btu coal is sold to cement manufacturers in New Mexico, Arizona, and Mexico. Much of the coal mined at King Coal is hauled by truck to rail lines in Gallup, New Mexico and to cement plants in Tijeras, New Mexico. King Coal expects to open a new mine in the next few years called the King II Mine. The Cumbres & Toltec Scenic Railroad and the Durango & Silverton Narrow Gauge Railroad both purchase about 5,000 tons per year nut or lump coal from King Coal.

The New Horizon Mine in Montrose County near Nucla supplies the Tri-State Generation and Transmission's Nucla Power Plant. A new exploration program to extend the life of the mine is active. New Horizon reclaims about 25 acres per year.

THE NATIONAL COAL OUTLOOK

The U.S. consumes over 1 billion tons of coal per year representing a major energy resource for America's domestic supply. The U.S. imports 65 percent of the oil, 16 percent of the natural gas, and nearly all of the uranium consumed annually in the country. Alternatively, coal is a net energy export product, by about 50,000 short tons annually. The U.S. economy is tied directly to electricity use and if natural gas supplies decline in the future, the only remaining real solution for baseload electric generating fuel is either coal or nuclear. For now coal will remain critical to the future of electrical generation.

On July 17, 2006, the Southern States Energy Board, a cooperative group of government and private individuals from the energy industry, initiated the American Energy Security Study. This is an interstate compact organization of 16 fuel-producing states that have joined with state and federal regulators to create a plan for America to establish energy security and independence. This plan calls for curbing imported energy through the production of alternative transportation fuels from our vast domestic resources such as coal, biomass, and oil shale. The plan also emphasizes the need and opportunity for domestic carbon dioxide enhanced oil recovery and sequestration programs, increased voluntary transportation fuel efficiency, and energy conservation.

The challenge becomes how to balance the future role of coal in a world where there will be constraints on carbon dioxide emissions while still utilizing coal to meet growing energy needs worldwide. On August 2, 2006, the U.S. Department of Energy (DOE) reported a surge in proposed coal-fueled power plant construction in the country. They noted that 153 new coal-fired electricity plants could be built by 2025. This represents 93 gigawatts of new electric baseload capacity. DOE estimates that 154 gigawatts of coal-fired electricity capacity will be needed by 2030 to meet America's increasing needs for energy. Illinois, Texas, Florida and Kentucky head the list of states planning to build new coal plants, each an importer of Colorado coal.

Net generation of electricity in the U.S. is primarily from coal. As of November 2006, coal accounts for 48.8 percent of the nation's electricity. According to a March 2007 report by Massachusetts Institute of Technology, "Coal can provide usable energy at a cost of $1–$2 per million Btu (MMBtu), as compared to $6–$12 per MMBtu for oil and natural gas." They further conclude that coal use will increase under any foreseeable energy supply scenario because it is cheap and abundant. Carbon-free technologies, chiefly nuclear and renewable energy for electricity, will also play an important role in a carbon-constrained world, but absent a technological breakthrough, coal, in significant quantities, will remain a critical resource.

CLEAN COAL TECHNOLOGIES

Much has been stated of late about alternative technologies for coal. "Clean coal" is defined as coal that is chemically washed of mineral impurities and sometimes gasified and burned. On March 4, 2007, the Associated Press reported that the U.S. government awarded $385 million in grants for ethanol production. Six projects were chosen, and three of these were related to coal gasification. Long used as a method for generating electricity, coal might also provide a faster and cheaper way to produce ethanol from biomass.

The Energy Act of 2005 contains provisions that authorize federal government assistance for integrated gasification combined cycle (IGCC) or pulverized coal advanced technology projects with or without carbon capture and sequestration. Xcel Energy is proposing a test plant in Colorado to assess IGCC technology at high altitude. This plant would convert coal to a cleaner-burning gas and allow for capture and sequestration of carbon dioxide, a contributor to greenhouse gas emissions. Xcel Energy is considering two possible sites in eastern Colorado for the plant site and will select one later in 2007.

IGCC technology is a lower cost solution than pulverized coal with carbon dioxide capture. This $0.5–$1 billion project will convert coal to hydrogen gas. This gas is then burned to create steam for conventional turbine electrical generation. The process facilitates the collection of sulfur dioxide, nitrogen oxides, and carbon dioxide from the flue gas. The hydrogen gas can be used as an alternative fuel, while the carbon dioxide can be sequestered underground in geologic environments such as saline aquifers and depleted oil fields. This approach could be one of several solutions used to reduce greenhouse gas emissions. There are currently about 40 pilot demonstrations underway to test the efficiency of geologic carbon storage throughout the U.S. These projects are funded by the DOE National Energy Technology Laboratory, and the Colorado Geological Survey is participating in three of these pilot studies. Carbon sequestration is being done in Canada, Algeria, and Norway. Xcel Energy hopes to be the first to demonstrate that IGCC technology with carbon capture works effectively at high altitudes (such as in Colorado). Xcel Energy estimates that they will remove about 2.3 million tons per year of carbon dioxide from the proposed 600 Mw IGCC plant. Assuming a 40 year plant life, there will be nearly one trillion tons of captured carbon to sequester (G. Young, personal communication).

There has been much interest lately in converting coal to liquid diesel fuel. This revived technology would augment the nation's conventional diesel fuel supply. A Denver-based company, KFx Inc., is working on a pilot project for coal gasification and liquefaction in the Powder River Basin in Wyoming using subbituminous, high moisture coal. Colorado coal, with its high heat value and low moisture content, makes gasification technology attractive; however Wyoming is leading the research. KFx recently announced initial agreements with two utilities for development of their K-Fuel plant technology, which uses the new fuel developed by the company. However, conventional energy resources have higher energy densities per unit volume than other sources such as ethanol or hydrogen.

CONVENTIONAL ENERGY RESOURCES: URANIUM

INTRODUCTION

The steep rise in uranium prices since 2003 accelerated in 2006 and the gap between supply and demand widened. The spot price for uranium oxide (U_3O_8) reached a high of $65 per pound by the end of 2006 (and has reached as much as $91 per pound in early 2007, fig. 37). This is the highest price ever. The reason for the price acceleration is a combination of real and anticipated demand accompanied by low production.

In 2003, the Chinese government announced plans to build up to 40 new nuclear plants; India will have 7 new plants coming on line by 2008 according to the Nuclear Power Corporation of India; France, Japan and South Korea have announced plans for building additional reactors. In the U.S. there are currently 104 licensed commercial nuclear reactors, generating approximately 20 percent of the domestic electricity use. Although no nuclear plants have been licensed since 1973 and no plants have come on line since 1996, there appears to be sentiment among policy makers that additional nuclear generating capacity is needed in the U.S. Even with the current plants, owners and operators of U.S. civilian nuclear power reactors purchased 66 million pounds of uranium oxide equivalent during 2005 (U.S. Energy Information Agency.) That same year, total production of uranium concentrate in the U.S. was less than 3 million pounds. The difference was made up from sources such as imported uranium oxide and decommissioned Soviet nuclear warheads. While U.S. demand increased to greater than 66 million pounds in 2006, the stockpile of material available for decommissioning is running out, so the shortfall must be made up somehow. (Energy Information Administration)

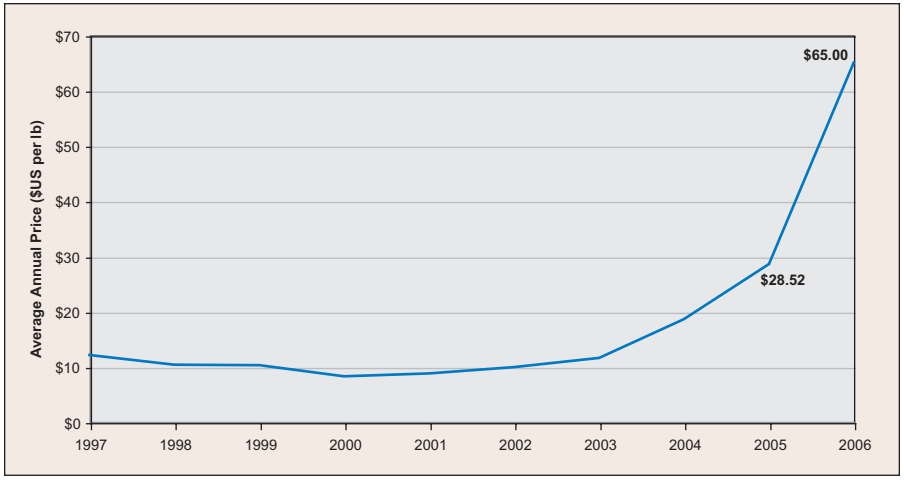

Figure 37. Average annual spot price for uranium oxide (U_3O_8) from 1997 to 2006. Data source: The Ux Consulting Company, LLC. http://WWW.uxc.com/.

Table 15. Total uranium mine permits in Division of Reclamation, Mining, and Safety system. "Other status" can include terminated, denied, inactive, revoked.

County	Active Permits	Other Status Permits (includes terminated)	Total Permit Actions
Fremont	0	2	2
Jefferson	1	0	1
Mesa	0	30	30
Moffat	1	0	1
Montrose	16	55	71
Park	0	1	1
Rio Blanco	0	2	2
Saguache	1	0	1
San Miguel	14	33	47
Teller	0	1	1
Weld	0	2	2

Currently one of the bottlenecks in the U.S. uranium supply chain is in milling capacity. At the end of 2006, there was only one active mill capable of processing conventionally-mined uranium ore in the U.S. There were five *in-situ* leach plants producing ore; these operations do not require a mill to process the ore. Discussions with professionals in the mining industry reveal that a number of uranium mines could begin production rather quickly if mill facilities existed to receive their product. Table 15 shows the number of active uranium mine permits in the Colorado Division of Reclamation, Mining, and Safety system by county; this provides a good indication of where uranium exploration and mining will occur in the future.

The worldwide demand for uranium by nuclear power generation is approximately 68,000 tons per year (Uranium Information Centre). Since 2000, the equivalent of 9,000 tons of uranium per year has been derived from the decommissioning of nuclear weapons. The U.S. ranks fourth in known recoverable resources of uranium behind Australia, Kazakhstan, and Canada (International Atomic Energy Agency.) Colorado is grouped with Arizona, New Mexico, and Utah of the Four Corners region as hosting the greatest reserves of uranium in the U.S. with 123 million pounds estimated reserves.

URANIUM EXPLORATION AND DEVELOPMENT

A great deal of activity was generated in the exploration and development of uranium properties in Colorado in 2006. Table 17 (located in Non-energy Resources section) shows the number of claims filed with the Bureau of Land Management Colorado State office for 2006. While identification of the mineral commodity is not required for a claim, 60 percent of claims filed in 2006 (3,404 of 5,693) are located in counties for which the claims are almost certainly for uranium. Those counties are Dolores, Mesa, Moffat, Montezuma, Montrose, Rio Blanco, and San Miguel. The uranium business strategy in Colorado has been one of active and aggressive maneuvering by companies to obtain properties with potential, characterized by numerous acquisitions, takeovers and joint ventures. Most of the recent activity has been on properties with historic production, many of which still have proven reserves that can once again be profitable. The following is a list of companies actively involved in exploration and/or development of uranium in Colorado.

Blue Rock Resources Ltd

Blue Rock Resources, Ltd, of Vancouver, B.C., has interests in two areas of historic uranium production in Colorado. The company has an option agreement to form a joint venture on the Skull Creek Project in Moffat County with Energy Metals Corporation. The Skull Creek project comprises 197 claims covering approximately 3,940 acres on Bureau of Land Management (BLM) land and 1,280 acres on Colorado State Land Board leases. Uranium mineralization occurs in three steeply-dipping lignite coal beds within the Sego Sandstone on the northern limb of the Red Wash Syncline. One of the beds shows continuous mineralization over a strike length of 12 miles. According to press releases by the company, Blue Rock is actively working to secure a permit for the reopening and resampling of the Blueflame adit in the second quarter of 2007. The company plans to follow this work with a drill program targeting the near surface (less than 30 meters depth) high grade (0.6 to 1.2 percent U_3O_8) mineralization as reported in historical work on the Skull Creek Project.

Blue Rock also holds an option to lease a second Colorado project. The Tramp Mine project in the Uravan district of Montrose County consists of eight claims encompassing the underground Tramp Mine and mine site with an additional 51 claims staked immediately adjacent to the mine site. The Tramp Mine is currently permitted and has operated sporadically from the 1950s with historic production from the Morrison Formation reported to grade 0.28 to 0.32 percent U_3O_8. Vanadium is present at grades of 1.5 to 1.7 percent V_2O_5. Company management feels that the properties adjacent to the mine have never been carefully assessed and are anticipating their planned drilling program will show additional reserves.

The Cotter Corporation

The Cotter Corporation is a subsidiary of General Atomics Corporation of San Diego. The company is a long-time producer of uranium in Colorado. They produced 255,544 pounds of U_3O_8 from mines in the Uravan district as recently as 2005, but temporarily closed the mines in November of that year because of the unfavorable economics of hauling the ore 300 miles to their mill in Cañon City for processing. The mill has a nominal capacity of 1,200 tons per day and is licensed to process a wide range of uranium-bearing feed material and performing specialized milling campaigns.

Most of Cotter's mines are located in the Uravan district, where the Salt Wash Member of the Jurassic Morrison Formation has been a consistent producer of uranium and vanadium ores. In addition to the recently-closed mines (the JD-6, JD-8, JD-9 and SM-18 mines), Cotter owns or controls eleven other uranium-vanadium mines in the Uravan district with a reported 20 million pounds of U_3O_8 as recoverable reserves. Cotter also owns the Schwartzwalder Mine in Jefferson County, a hard-rock underground mine in which the uranium mineralization occurs in veins in Precambrian metamorphic rocks. Total historic production from the Schwartzwalder has been approximately 17 million pounds of U_3O_8 with an additional resource of 16 million pounds identified. Based on earlier predictions of a weak uranium market, the mine was placed on a temporary standby status and reclamation initiated. An additional factor is the flooding of the mine. Discussions with a Cotter spokesperson indicate that the company is still working on their Cañon City mill. They intend to hold their properties and wait until the mill is operational before making a decision on further mining.

Denison Mines, Inc.

In late 2006, International Uranium Corporation merged with Denison Mines, Inc., of Toronto and assumed the name of Denison Mines Corporation. The company has been working to reopen a cluster of mines in the Uravan district in the Big Gypsum Valley of San Miguel County. Ore is being stockpiled from the Sunday, West Sunday, Saint Jude, Carnation and Topaz mines, and the company anticipates reaching a production of 550 tons per day by mid-2007. Ore will be shipped to the company's mill in Blanding, Utah. The company also has started developmental work and exploration drilling on additional claims adjacent to the existing complex. The uranium and vanadium mineralization in these mines (referred to as the Sunday—Saint Jude complex) occurs in channel deposits within the Morrison Formation.

Figure 38. Portal of the West Sunday Mine, in the Sunday-Saint Jude Mine Complex of Denison Mines, Inc., San Miguel County. (Photo by Chris Carroll).

Energy Fuels, Inc.

Energy Fuels, Inc. (EFI), is a Toronto-based mineral exploration and development company with uranium and vanadium projects in Colorado that it plans to operate through its wholly-owned Colorado subsidiary Energy Fuels Resources Corporation. EFI has been actively working on the Whirlwind property, which straddles the border between Mesa County, Colorado and adjacent Grand County, Utah. Crews have been renovating drifts and ventilation infrastructure and proceeding on the permitting process. The company is planning to have the Whirlwind producing in 2007, utilizing toll milling for the ore.

In late 2006, EFI obtained a permit to conduct their 2007 drilling exploration program on the MCT claim group in San Miguel County. The MCT claim group is one of seven acquired by the company from URenergy Properties. The MCT claims are located near the Sunday-Saint Jude mine complex operated by Denison Mines, Inc. and EFI geologists believe that the channel trend exploited in the that complex continues into the MCT claims group. Regarding mill availability, EFI had previously announced the possibility of constructing and permitting their own mill in southwestern Colorado. As of early 2007, those plans are in abeyance, but remain a possibility depending on the resilience of the uranium market.

Energy Metals Corporation

Energy Metals Corporation (EMC), of Vancouver, British Columbia, has been active in property acquisition in Colorado as well as other western states. EMC owns one of the largest databases on historic uranium exploration in Colorado. The company has two interests in Moffat County. One is the Skull Creek joint venture with Blue Rock Resources (narrative above); the second is the Maybell Project, listed as "advanced stage" by the corporation. The Maybell project includes 548 lode claims covering approximately 10,400 acres. The project was previously mined from 1957 to 1964, during which time Union Carbide produced 3.6 million pounds of U_3O_8. The company has also been very active in staking claims on BLM land in Moffat County.

A second Colorado project—the Hansen—was obtained by EMC when the company acquired Quincy Energy Corporation in late 2006. The Hansen property is located in the historic Tallahassee Creek district of Fremont County. The Hansen property has a long history under Cyprus Minerals and a series of subsequent owners, including commercial production of uranium. Uranium mineralization at Hansen is hosted by the Eocene-age Echo Park Formation, a series of interbedded sandstone, siltstone, claystone and conglomerate of fluvial origin. The mineralization occurs as stratiform lenses within units of the lower Echo Park Formation. Numerous historic reports estimate resources at the Hansen property from 18 million pounds to 33 million pounds. The company feels that further evaluation of the property is needed before work proceeds.

Homeland Energy Corporation

Homeland Energy (HEC) is a South African energy corporation conducting uranium exploration and development in Colorado through their wholly-owned subsidiary Homeland Uranium, Inc., of Vancouver, British Columbia, conducting their U.S. operations from an office in Grand Junction. The company has five properties in Colorado. The VEX property consists of 65 unpatented lode claims that span some 1,080 acres on BLM ground near Denison's Saint Jude complex in San Miguel County. Uranium mineralization occurs in the upper Salt Wash Member of the Morrison Formation at depths of approximately 750 feet below surface. The area is a former producer.

The TEX property includes 66 unpatented lode claims, all on BLM ground, totaling approximately 1,320 acres. The claims extend from the northwest limb of the Disappointment Valley syncline to near the top of the exposed Gypsum Valley anticline in San Miguel County. The geologic environment is the same as that at the VEX property and the nearby Saint Jude complex. There has been no historic mining on the property.

The CNX property, another prospect in the Salt Wash Member of the Morrison Formation, is Homeland's southernmost property in Colorado. It lies on the

northeast limb of the Dolores anticline, a major salt-formed structure and consists of 156 unpatented lode claims on BLM land, totaling approximately 3,080 acres. The Salt Wash member lies from 500 to 900 feet below ground surface on the property. The location is adjacent to the historically productive Centennial deposit. Although there are no historic mines adjacent to the Centennial, HEC officials believe that the channel hosting the Centennial deposit continues beneath the CNX property.

Another Uravan district property is the Norma Jean property, just west of the CNX location. The Norma Jean comprises 116 unpatented lode claims on BLM ground over 2,314 acres. Similar to the CNX property, the Norma Jean sits on the northeast limb near the crest of the Dolores anticline. There are several historic mines on the property including the Norma Jean, the Norma Jean #2, the Mayday, the Bessie, the Depression, the Paystreak and the Moqui Jug. Unlike the other nearby properties, these mines are developed in the middle Salt Wash Member. The two largest mines on the property produced 4,500 tons of ore at an average grade of 0.33 percent U_3O_8 and 1.92 percent V_2O_5. The company feels that the middle Salt Wash Member remains relatively unexplored, providing excellent potential for further exploration and development in the area.

Just north of Norma Jean and CNX is the Slick Rock property, encompassing 88 unpatented lode claims over approximately 1,690 acres on BLM land. Uranium mineralization occurs between 400 and 1,200 feet below the surface in an area which earlier drilling revealed favorable alteration in the upper Salt Wash Member. The property lies 1.5 miles west of the Burro mines which produced nearly 2 million pounds of uranium and the company feels the property is well-positioned to test for a channel system connecting the Burro with the Saint Jude mine complex.

Powertech Uranium Corporation

Powertech Uranium is a Vancouver, B.C. firm concentrating on uranium deposits that can be mined using the *in-situ* leaching process. The company is planning development of the Centennial project in Weld County using those techniques. The Centennial was discovered in the 1970s by Rocky Mountain Energy, who drilled over 900,000 feet of exploration holes from 1974 through 1984 and conducted a positive mining feasibility study. Their work identified 9.5 million pounds of uranium resource with an average grade of 0.07 percent U_3O_8 with another 3 million pounds possible. The mineralized zone occurs within channel sands in the Fox Hills Sandstone—a marginal marine horizon—from 120 to 620 feet beneath the surface. Powertech staff has brought twelve previous *in-situ* leaching programs on line and feel that the Centennial project has outstanding potential that can begin producing in three to four years.

sxr Uranium One, Inc.

A new player in the Colorado uranium arena is Toronto-based firm sxrUraniumOne. Early in 2007, the company acquired all the uranium properties of U.S. Energy Corporation, which includes the Burro Canyon project in San Miguel County, shared with Uranium Power Corporation.

UraniumCore Corporation

UraniumCore Company (UCC) is a junior exploration company from Seattle, Washington, actively focused on the acquisition of uranium projects. Most recently, UCC signed an agreement to acquire a majority interest in 88 unpatented claims in Colorado. Forty-two of the claims are in the Marshall Pass area of Saguache County where the Lookout Mine produced 514 tons of ore grading 1.17 percent U_3O_8 in the 1950s. The company considers the Marshall Pass property to resent a favorable exploration target to host a deposit similar to that at the nearby Pitch Mine, which produced 104,520 tons of ore with an average grade of 0.58 percent U_3O_8.

The other 46 claims lie in the area of Jamestown in Boulder County. These claims cover the Fairday Mine, which produced more than 182,000 pounds of U_3O_8 with an average grade of 0.44 percent from a Tertiary vein system. These claims are considered favorable exploration targets for location of a deposit similar to the Schwartzwalder Mine. The Schwartzwalder is Colorado's largest uranium mine, having produced in excess of 17 million pounds of U_3O_8 from a similar vein system in nearby Jefferson County.

RENEWABLE ENERGY RESOURCES

INTRODUCTION

Governor Bill Ritter, Jr. outlined a top-priority plan on January 16, 2007 to build the state's economy around renewable energy. This plan includes new transmission lines, more electricity from alternative energy sources, and building the reward programs for households and businesses that participate in alternative energy electricity generation. The Governor plans to make Colorado the nation's capital for renewable energy development. With the National Renewable Energy Laboratory (NREL) located in Golden and considered the nation's number one source for alternative energy, Colorado will hopefully become the focus for renewable energy technology.

On March 28, 2007 House Bill 1281 was signed into law by Governor Ritter. This bill mandates that power companies and electric cooperatives generate 20 percent of their electricity from various renewable sources by 2020. This doubles the ten percent previously mandated by Amendment 37, which was voted into law in 2004 by Colorado citizens. The plan calls for more wind, sun, and biomass powered alternatives, as opposed to the traditional hydroelectric power. The Bill also sets the first renewable energy standard for rural electric cooperatives in Colorado. We are situated in a unique location for alternative energy technology. The mountainous elevation and high plains are good territory for hydroelectric, wind, geothermal, and solar energy. Although hydropower is also ideal for Colorado, it is limited in the Bill to only 10 Megawatts (Mw) or less per new hydroelectric unit.

At the Colorado New Energy Summit in Denver recently the Governor mentioned using $10 million in State gaming fees to promote alternative energy in the form of rebates to homeowners who invest in alternative energy. According to the governor Colorado is ranked 11th in wind energy potential, is the sixth sunniest state, and the fourth highest possibility for geothermal energy. U.S. Senator Ken Salazar, at the same conference, said that $3 a gallon gasoline, the threat to national security, and global warming are driving the need for more renewable energy. Colorado has the resources to develop solar, biomass, and wind technology.

WIND ENERGY

Wind energy is defined by the process in which kinetic energy in wind is transformed into mechanical power to generate electricity. Wind power is the fastest growing source of electricity generation in the nation. From November 2005 to November 2006 wind-powered electric generation increased by 44.7 percent nationally. It is just a small segment of the total electrical generation capacity at 0.6 percent, but is growing quickly.

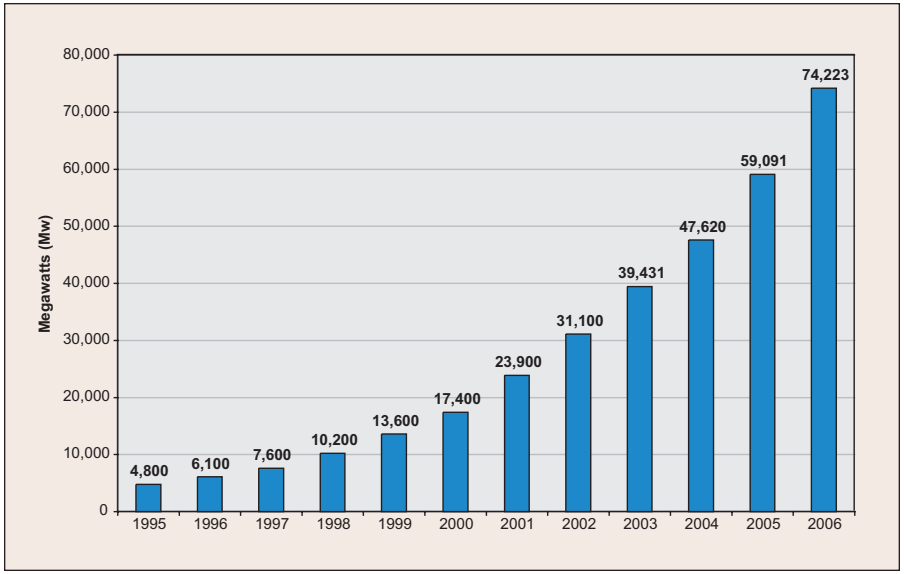

Figure 39. Net generating capacity for worldwide wind capacity. (American Wind Energy Association).

Wind power is a growing segment of the global electric generation market. According to the American Wind Energy Association (AWEA), 2006 was a record year worldwide for the production of wind energy (fig. 39). Installation of new wind units increased from 11,769 Megawatts (Mw) to 15,197 Mw worldwide from 2005 to 2006. This makes the total global installed wind energy capacity 74,223 Mw, up from 59,091 Mw in 2005. Germany leads the world with 20,000 Mw capacity, while Spain and the U.S. are tied for second with 11,000 Mw capacity each. In 2006, the U.S. led the world in new installed wind units with 2,454 Mw capacities.

Jens Soby, president of Vestas Americas, a subsidiary of the Danish company Vestas Wind Systems that make many of the new wind turbines, announced plans at the New Energy Summit to build a $60 million turbine blade manufacturing plant in Windsor, Colorado in 2008. The company will employ about 464 people in their first manufacturing facility in the U.S. The Larimer County plant will produce 1,200 wind turbine blades per year.

BP Alternative Energy North America, Inc. purchased Greenlight Energy last year. BP is moving forward by planning new wind farms in Colorado. They plan

to build five new wind power projects in 2007. The Cedar Creek wind farm in Weld County will have 274 turbines, the biggest yet in the state. The turbines will have the capacity to supply electricity to 120,000 customers. The 32,000 acre facility will be built beginning in the fall of 2007. BP is partnering with Babcock & Brown Operating Partners to build the facility. Babcock & Brown is one of the five largest owners of wind energy installations in the U.S. Electricity will be sold on a long-term contract to Xcel Energy. Table 16 lists the wind energy developments in Colorado.

Xcel Energy offers an alternative energy program for its customers. Called the *Windsource* program, the customer is able to choose how much wind energy they want to support. The amount you choose is variable up to 100 percent, and is capped by the amount of wind energy available to purchase. Benefits of purchasing wind power are derived from the fact that wind energy is produced without air pollution emissions such as sulfur dioxide, nitrogen dioxide, and carbon dioxide. However, one downside to wind is that electricity is only generated when the wind blows and the power cannot be stored with current technology.

Other utilities are following suite. The Platte River Power Authority operates the Rawhide coal-fired power plant in Wellington, Larimer County. They supply northern Colorado with electricity, and also purchase electricity from the Medicine Bow Wind Project west of Laramie, Wyoming. In 2006, they purchased the equivalent of 198,618 megawatt-hours of power from that unit to supply the Ft. Collins area with electricity. Colorado Springs Utilities also offers a wind power alternative to its customers, called *Green Power*, which is currently sold out. With the new legislation all of the state's rural cooperative electricity suppliers must also supply 20 percent of their electricity from alternative sources.

Not only is wind power gaining in popularity in Colorado it may also be turning out cheap energy (fig. 40). According to the Earth Policy Institute, Xcel Energy's 33,000 *Windsource* customers pay about $6 more each per month for their electricity. However, in a two-month window in February and March 2006, those customers were paying slightly less than those using conventional electricity because the price of coal and natural gas had temporarily increased. Xcel is soliciting proposals from wind developers for up to 775 megawatts of new wind power generation. Currently Xcel Energy meets its renewable energy credit goals.

Regulatory rules for transmission lines make it difficult to get electricity from wind energy to the customer. Electricity transmission from the turbines to the customers is difficult because of the remoteness of the wind farms. Senate Bill 100 was also signed by the Governor on March 28, 2007 which allows utility companies to recoup the cost of new transmission lines. This will help to get new high-voltage transmission lines built for wind-power, which cost about $1 million per mile. Strong winds tend to blow in sparsely populated areas, but electricity is needed in urban areas.

Figure 40. Ponnequin Wind Farm, Weld County.

Table 16. Wind energy developments in Colorado. Mw = Megawatts (American Wind Energy Association).

Project	Owner	Date Online	Mw Capacity	Power Purchaser	No. Units	Turbine Type
Ponnequin EIU 1	K/S Ponnequin Windsource & Energy Resources	1999	5.1	Xcel Energy	7	NEG Micon
Ponnequin Xcel 2	Xcel	1999	16.5	Xcel Energy	22	NEG Micon
Ponnequin EIU 3	New Century	2001	9.9	Xcel Energy	15	Vestas
Peetz Table Wind Farm	New Century	2001	29.7	Xcel Energy	33	NEG Micon
Colorado Green, Lamar (Prowers Co)	Xcel/GE Wind Corp.	2003	162	Xcel Energy	108	GE Wind 1.5 Mw
Prowers Co (Lamar)	Arkansas River Power Authority	2004	1.5	Arkansas River Power Authority	1	GE Wind 1.5 Mw
Baca Co (Springfield)	Arkansas River Power Authority	2004	1.5	Arkansas River Power Authority	1	GE Wind 1.5 Mw
Prowers Co (Lamar)	Lamar Utilities Board	2004	4.5	Lamar Utilities Board	3	GE Wind 1.5 Mw
Aurora Wal Mart	Bergey Windpower	2005	0.05	WalMart	1	Bergey Windpower 50 kW
Spring Canyon	Invenergy	2006	60	Xcel Energy	40	GE Wind 1.5 Mw

As part of the federal government's commitment to alternative energy, a $2 million research project was announced in December 2006 that would combine two renewable energy technologies. Xcel Energy and NREL will develop the technology at the National Wind Technology Center south of Boulder. It will use wind power to ultimately produce hydrogen fuel. Wind generated electricity will be used to break down water particles into hydrogen and oxygen. The hydrogen is captured and stored for high-tech fuel vehicles. If successful it will be the first attempt at storing energy from wind in the form of hydrogen fuel. The future use will be for fuel cell powered vehicles and in the distant future, electricity.

HYDROELECTRIC POWER

Colorado's mountainous terrain has great potential for hydroelectric power and has maintained a substantial amount of hydroelectric power generation. Approximately five percent of our total electrical output comes from hydroelectric power. Aspen, Telluride, Durango, Ouray, Nederland and other mountain towns supply much of their power from several nearby hydroelectric stations. The Colorado-Big Thompson Project brings large volumes of western slope water via tunnels under the Continental Divide to the Front Range. Along the way hydroelectric power is generated at several substations.

The city of Boulder sells hydroelectric power to Xcel Energy that supplies electricity to about 8,000 homes. Renewable energy is a priority for the city which voted for a "carbon tax" in November 2006 that may help Boulder reduce greenhouse gas emissions. Boulder is voluntarily trying to meet the Kyoto greenhouse gas reduction standards, and will use the hydroelectric renewable energy credits toward that goal.

SOLAR ENERGY

There are two main areas of concentration for solar energy research: solar thermal and photovoltaic (PV) research. NREL in Golden conducts research on both programs. Their solar thermal program looks to analyzing cost and improving performance for new solar systems and developing parabolic trough technology for solar electric generation. Their photovoltaic research is based on materials research, developing new PV cells, and assisting the PV industry with manufacturing of better PV materials and products. The National Center for Photovoltaics is located at NREL, which works on increasing the efficiency of PV systems.

In February 2007, the Public Utilities Commission approved a proposal from Xcel Energy to build a $60 million state of the art solar energy facility in the San Luis Valley. Located north of Alamosa in the sunniest part of Colorado, the solar power plant will potentially generate up to eight Mw of solar electricity. The plant will use PV panels that directly convert sunlight to electricity without the use of turbines. SunEdison, LLC, is partnering the project with Xcel, which will be capable of generating enough electricity for 1,650 homes. This will be the largest facility of its kind in the U.S. Xcel chose PV technology over solar thermal because the technology of solar thermal, which generates electricity with turbines, was not fully developed for the project. Xcel hopes to expand its solar energy program by partnering with other companies in the future to meet the state's new renewable energy standards.

BIOMASS, ETHANOL, BIOFUELS

The Governor's new plan provides incentives for universities to conduct biomass research. On March 12, 2007, the U.S. Senate Agriculture Committee chairman Tom Harkin of Iowa toured the NREL plant with Colorado Senator Ken Salazar. The new federal farm bill will include funding for renewable energy and Colorado agriculture will play a significant role. NREL is conducting research on converting wood chips, grasses, and other plant cellulose into ethanol for vehicular fuels. Colorado has two ethanol plants and two more under construction. A growing concern for ethanol is the large use of groundwater. Current technology uses four gallons of water for every one gallon of ethanol produced. Today the typical ethanol plant produces in one year what a large gasoline plant makes in one day. And, ethanol cannot be transported easily in the existing pipeline system because it absorbs water and leads to corrosion.

The Colorado Biomass Information Clearinghouse is the main Colorado source for biomass data. It defines biomass as any organic matter other than coal that can be processed into energy for heat, liquid fuels, or electricity. Sources include wood, plants, agriculture and residue, animal waste, and industrial wastes. The biomass resource estimate includes forest biomass from forest thinning and urban wood waste from landscaping. It is estimated that 55 Mw of renewable electric power could be generated from biomass. Agricultural crop residue can be collected and converted to alternative fuels as well. Biogas collected from covered waste lagoons at animal feeding operations can be used to generate heat and electricity. Weld County has the best potential with over 105 covered animal waste lagoons.

GEOTHERMAL ENERGY

The U.S. Department of Energy developed the GeoPowering the West program in 2000. It consists of a program to utilize and identify opportunities for geothermal projects in the future. Colorado is one of the western states receiving support for a working group to study geothermal power. The first State Working Group meeting was held on January 31, 2007. Focus among the 90 participants was on geothermal energy, electricity production, direct-use and district heating, and geothermal heat pumps.

In 2006, the Colorado Geological Survey (CGS) began conducting new research on geothermal resources in the state. Currently work is progressing on a new heat flow map and a geothermal gradient map of Colorado. These maps are incorporating data from several existing geothermal databases, as well as new data from mineral exploration and petroleum wells. Preliminary results indicate high heat flow in several areas of the mountainous region of Colorado. Promising areas for geothermal energy development (electrical or direct use) include Mount Princeton (Buena Vista), eastern San Luis Valley, Pagosa Springs, Rico, Ouray, Steamboat Springs, parts of Gunnison County, and west of Trinidad, These results were a key part of presentations to the Geothermal Working Group in January 2007.

Currently, no electricity is produced from geothermal resources in Colorado. However, as a result of the State Working Group meeting, private-sector interests are evaluating the potential for electrical power generation using "binary system" power plant technology at some of Colorado's geothermal sites. Binary system power plants use a working fluid with a lower boiling point than water and, therefore, can produce electricity with lower temperature water than conventional geothermal power plants.

Direct-use consumers are increasing in numbers as expensive fossil fuel prices make geothermal alternatives more attractive. More residential heating customers are turning to direct-use geothermal heat pump applications. Commercial direct-use geothermal applications vary from heating an alligator farm in Alamosa County to heating a greenhouse in Chaffee County. In Pagosa Springs and in Steamboat Springs heating of public buildings has been in operation for decades. This type of direct geothermal energy use has potential for expansion in the state.

The Geo-Heat Center at the Oregon Institute of Technology identified 15 communities in Colorado that are within five miles of a geothermal resource with a temperatures of 122˚F or more, making them good candidates for community district heating or other geothermal use.

Geothermal heat pumps (also known as geoexchange, ground source heat pump) are also increasingly being used in residential and commercial settings. The Delta-Montrose Electrical Association offers incentives to encourage customers to install heat pumps. This limits the utility's peak loads and lowers customer utility bills. They report that the savings payback on initial capital investment for many systems is three to nine years.

NON-ENERGY RESOURCES

INTRODUCTION

Overview of 2006

Nonfuel mineral production includes metals, industrial minerals and construction materials such as sand and gravel aggregate. The Colorado Geological Survey (CGS) estimates that the total value of nonfuel minerals produced in Colorado in 2006 was $1.762 billion, compared to the final revised 2005 value of $1.789 billion. Of that 2006 total, $1.081 billion is from metal mining. These estimates have been compiled from information obtained by CGS from mine operators, news articles, corporate press releases, annual reports of public companies and from preliminary estimates released by the U.S. Geological Survey Minerals Information Team. The 2006 production value for all non-fuel minerals represents a 4 percent decrease from 2005. This drop can largely be attributed to the absence of vanadium production in 2006 and a lower price for molybdenum. Colorado still ranks 12th among the states in nonfuel mineral value, down from 9th position in 2005.

Gold reached a high of $725 per ounce in 2006, with an average price of $610 per ounce for the year. This trend continues the gold price rise that started at $260/ounce in March of 2001. The molybdenum market has been driven primarily by expansion of the steel industry in developing nations (mainly China). There was a decrease in the average annual price of molybdenum from 2005 to 2006, from a high of $32/pound in 2005 to an average of $26.50/pound in 2006. Even still, the price remained at a level nearly eleven times that seen at the recent market low in 1994. The lower molybdenum price was also a factor in Colorado dropping from 9th to 12th position in value of production nationally, as the state is a major producer of that commodity.

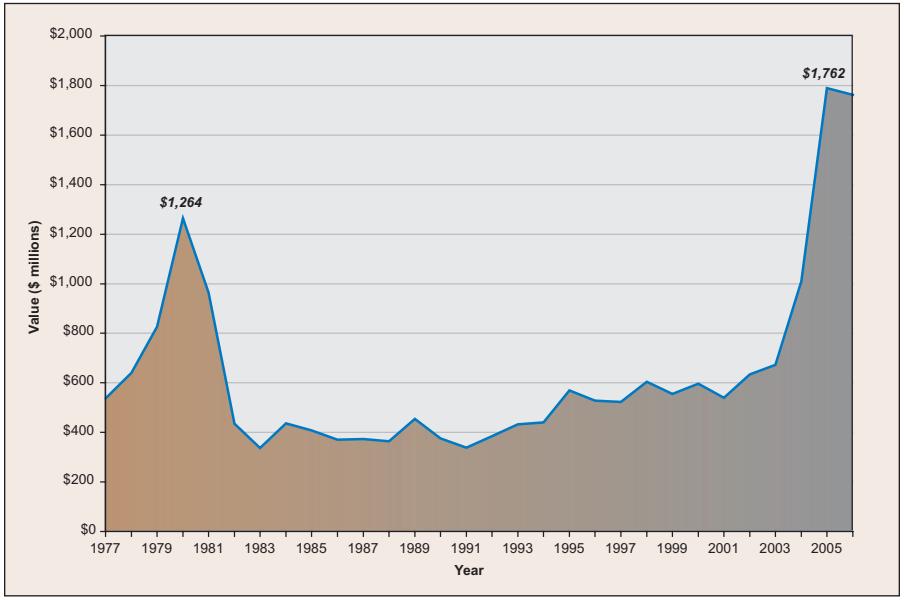

Figure 41. Colorado nonfuel mineral production value, 1977 to 2006 (estimated).

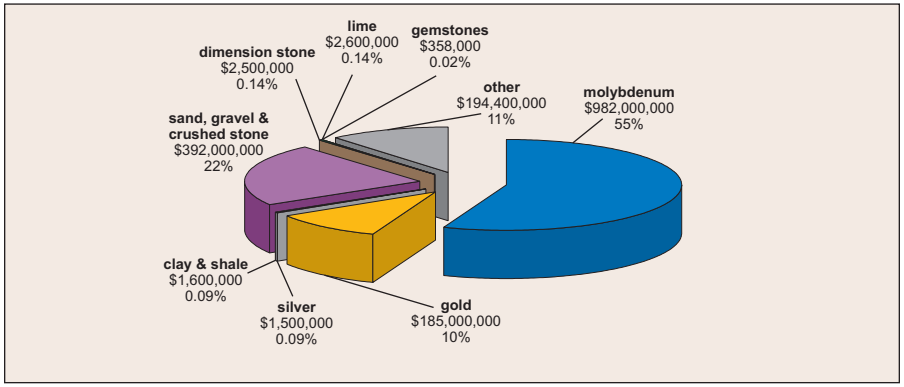

Figure 42. Estimated production value of nonfuel minerals in Colorado, 2006. "Other" Includes cement, soda ash, sodium bicarbonate, gypsum, helium and bentonite.

There has been a growing disparity between supply and demand for many mineral commodities, including several produced in Colorado. That growing demand has driven price increases which have, in turn, led to increased exploration activity. According to the Metals Economics Group, an organization that tracks trends in the mining industry, exploration expenditures reached record levels in 2006 for gold, base metals, molybdenum, mineral sands and industrial minerals.

One indicator of increased exploration activity with Colorado is the number of mining claims filed on federal lands in Colorado. A mining claim provides exclusive rights to the filer to develop the parcel for minerals. The number of active claims increased nearly 50 percent between 2004 and 2005 to approximately 8,000. In 2006, an additional 5,693 claims were filed, representing an additional increase of 70 percent for that one year. While the data are not available for the commodity target at each claim, the distribution of claims indicates that the great majority of these claims were filed for uranium, based on the counties in which they were filed. Table 17 lists the number of new claims filed in 2006 by county.

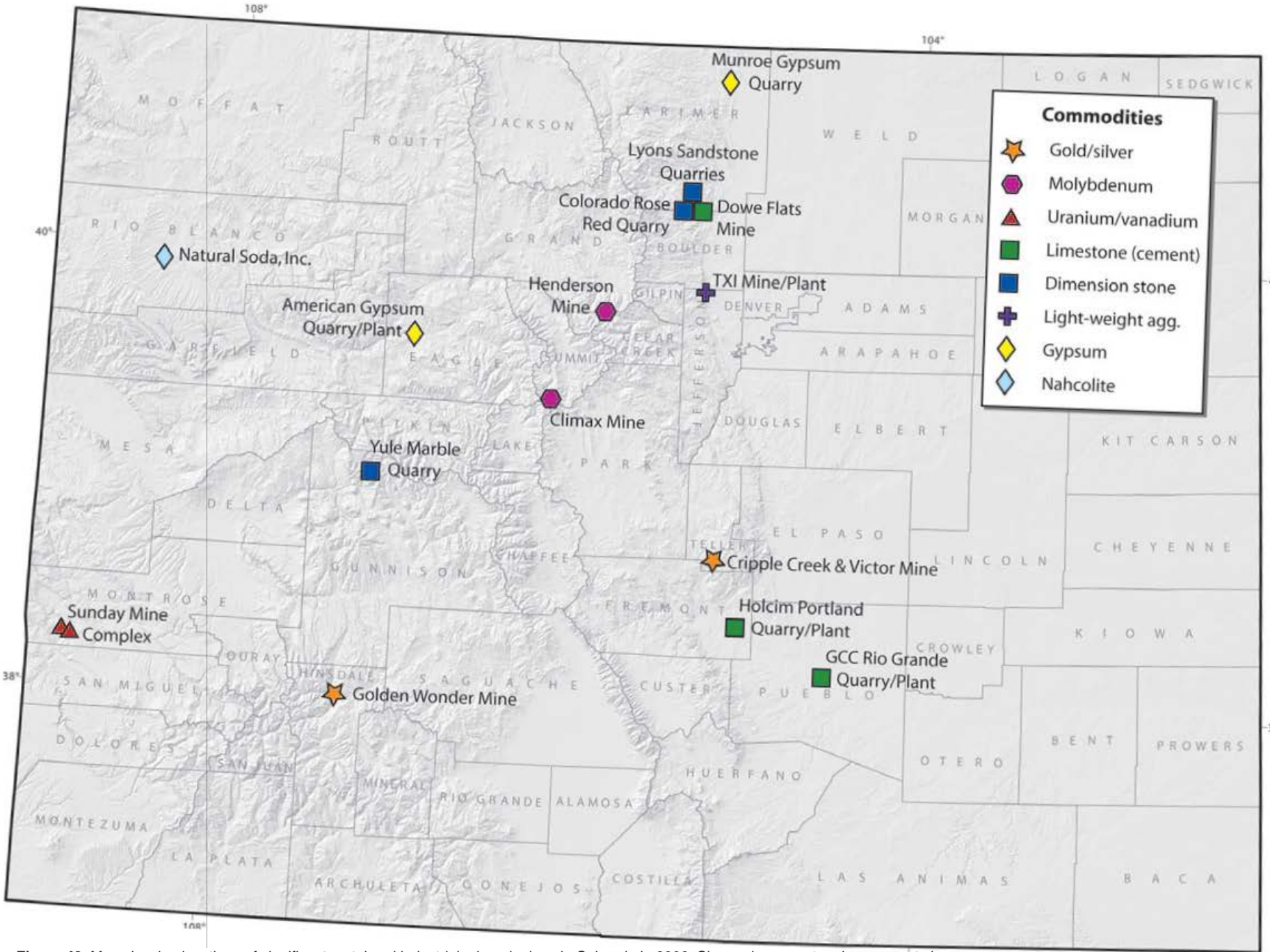

Figure 43. Map showing locations of significant metal and industrial mineral mines in Colorado in 2006. Clay and aggregate mines are not shown.

Table 17. Colorado mining claims filed in 2006 by county. Unlisted counties show no claims filed in 2006. Data not available for commodity, but an * marks those counties for which a high likelihood exists that most, if not all, claims are filed for uranium prospects. (Bureau of Land Management)

Boulder	75	Huerfano	2	Ouray	36
Chaffee	175	Jackson	4	Park	601
Clear Creek	10	Jefferson	5	Pitkin	15
Dolores*	169	Lake	40	Rio Blanco*	110
Eagle	1	LaPlata	155	Routt	2
Fremont	358	Mesa*	253	Saguache	49
Gilpin	28	Mineral	1	San Juan	65
Grand	6	Moffat*	541	San Miguel*	1731
Gunnison	16	Montezuma*	119	Summit	82
Hinsdale	20	Montrose*	995	Teller	17
				TOTAL	**5693**

Colorado, through the Division of Reclamation, Mining, and Safety (DRMS), issues permits for actual exploration and mining activities that disturb the land surface. Data for mines permitted and permit applications for the state in 2006 were obtained from the DRMS (tables 18 and 19). Those data show that most of the new permitting activity in 2006 was for construction materials (sand/gravel/aggregate). Activity was not abnormally high in 2006, indicating that the anticipated increase in activity for uranium has not progressed to the permitting stage.

Table 18. 2006 Colorado mining permits by county.

County	Permits Issued	*Permits Pending*	County	Permits Issued	*Permits Pending*
Archuleta	1	0	Logan	2	1
Baca	3	0	Mesa	3	1
Chaffee	1	0	Moffat	0	1
Crowley	0	1	Montezuma	1	1
Delta	5	0	Montrose	0	1
Dolores	1	0	Morgan	1	0
El Paso	1	1	Park	1	1
Fremont	2	2	Phillips	2	0
Garfield	4	3	Prowers	0	1
Grand	1	1	Pueblo	0	1
Gunnison	0	1	Rio Blanco	2	2
Huerfano	1	1	Routt	2	1
Jackson	1	0	San Juan	1	0
Kit Carson	3	0	San Miguel	0	1
Lake	0	1	Sedgwick	1	0
LaPlata	0	1	Teller	1	0
Larimer	2	3	Weld	3	4
Las Animas	2	1	Yuma	2	1
Lincoln	1	0	**Total**	**50**	**33**

Table 19. Commodities for approved mine permits—year 2006

Sand/gravel/aggregate	40	Shale	1
Stone	6	Oil shale	1
Peat	1	Gold	1

METALS MINING

The bull market in the metals industry continued through the year 2006. While the prices of several commodities declined from the average of the previous year, the market remained high. CGS estimates that the value of metals mined in the state in 2006 exceeded a billion dollars ($1.082 billion). This figure represents a slight decline from the revised final figures for 2005 of $1,176 billion. The average price for molybdenum decreased from 2005, while the average price for gold and silver both increased. Colorado is the leading molybdenum-producing state in the U.S. and is ranked 4th in production of gold. Silver is produced as a by-product of gold mining.

Metals exploration activity was booming in 2006 across the world. Sharp declines in metal prices in the years 1998–2002, and the resultant drop in exploration activity has left a large gap in the pipeline from exploration to production. Because of this gap, supply has not been able to catch demand. While current exploration will begin to identify new deposits, these will be years away from helping to fulfill the demand of growing economies.

The annual survey of worldwide nonferrous metal exploration expenditures by trade newspaper, *The Northern Miner,* shows that exploration budgets in 2006 totaled more than $7.5 billion, compared to a total of less than $2 billion as recently as 2002. The industry's largest trade show—the Prospectors and Developers Association of Canada—saw an increase in attendance at their annual convention to 17,600 in 2006, up from 14,000 in 2005 and 12,000 in 2004. As in the past, gold exploration leads the expenditures, although increases were significant in exploration for copper, platinum, diamonds, and zinc.

The most popular places to explore continue to be Latin America and Canada. While uranium exploration is booming in Colorado, there does not appear to be a commensurate increase in the search for metals. Several firms are finalizing projects in Colorado and exploring near to their current holdings, but activity seems to be light compared to the mineral wealth of the state.

Molybdenum

Colorado is the leading molybdenum-producing state in the U.S. In 2006, the production from the Henderson Mine near Empire in Clear Creek County was approximately 16,815 metric tons or just over 37 million pounds. This figure represents 28 percent of U.S. production, fully nine percent of worldwide molybdenum production. The U.S. is a net exporter of molybdenum. The average annual price of molybdenum rose from $8 per pound in 2003 to historical highs of more than $30

per pound in 2005, reaching a peak of $40 per pound in 2005. The price achieved an average of $26.50 per pound in 2006, yielding a value for 2006 of $982,380,000. That price is still very high compared to the 20-year average of $5.60 per pound. The rise and sustained high price is attributable to demand from China and a tight supply of high-quality western molybdenum. The high price has moved molybdenum to the position of the largest sector of the Colorado mining industry in terms of production value. Figure 44 shows molybdenum production in Colorado and the average price per pound of molybdic oxide from 1970 through 2006.

Uses of molybdenum

The uses of molybdenum are many and varied. The metal is a valuable alloying agent, providing hardness and durability to steel. Most high-strength steels contain molybdenum and molybdenum-alloy steel is a staple in gas and water pipelines around the world and in drill stem steel used in the oil and gas industry. The metal is used in electrodes for glass furnaces, in nuclear reactor vessels, rocket engine components, liquid metal heat exchangers, as a catalyst in petroleum refining and as a lubricant for high-temperature mechanical applications. A growing use is in double-hulled oil tankers. The uses in newly developed materials is expanding annually, as its physical and chemical characteristics of softness, ductility, very high melting point, and corrosion resistance are impossible to replace.

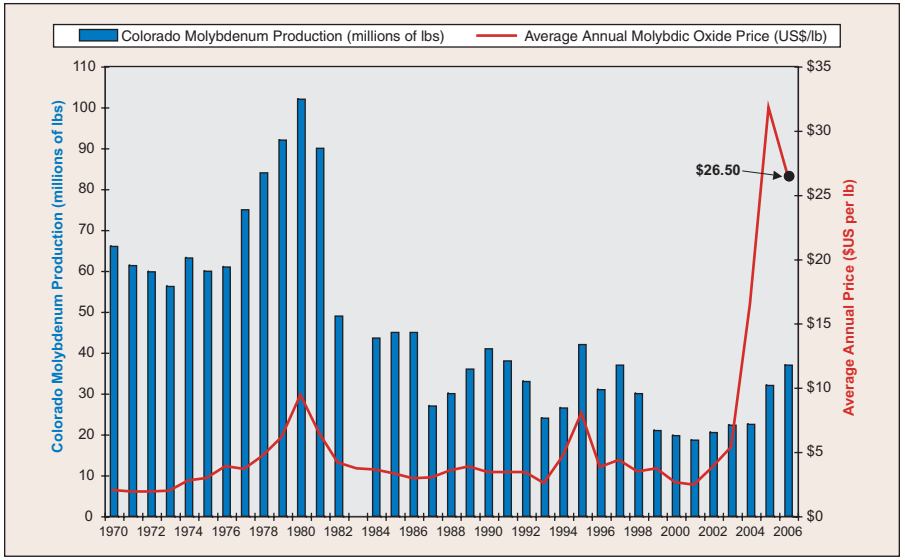

Figure 44. Molybdenum production in Colorado and average annual molybdenum price from 1970 to 2006. Data for recent years based on prices quoted in Platts Metals Week as reported by Phelps Dodge.

Henderson Mine, Clear Creek County

The Henderson Mine lies in the Front Range just west of Empire (fig. 45). The mine is the largest primary producer of molybdenum in North America. The underground block-cave mine is owned by Climax Molybdenum Company, a subsidiary of Phelps Dodge Corporation. (Phelps Dodge was acquired by Freeport-McMoRan Copper and Gold, Inc. on March 19, 2007.) The mine produced more than 37 million pounds (16000 metric tons) of molybdenum metal in 2006, a 15 percent increase from the 32 million pounds produced in 2005. At an average price of $26.50 per pound last year, the estimated gross value of the production was more than $982 million, a four percent decrease over the 2005 value of $1,022 million due to a lower price for the metal.

Ore from the Henderson Mine is transported to the mill in Grand County by a conveyer belt through a 10.5-mile-long tunnel beneath the Continental Divide. The sulfide concentrator at the Henderson mill is capable of treating 32,000 tons of ore per day. The mine ships most of its high-purity, chemical grade molybdenum concentrate to Fort Madison, Iowa, for further processing. Henderson has mined more than 170 million tons of ore and produced over 830 million pounds of molybdenum. Reserves are estimated at more than 150 million tons of ore containing over 500 millions pounds of recoverable molybdenum.

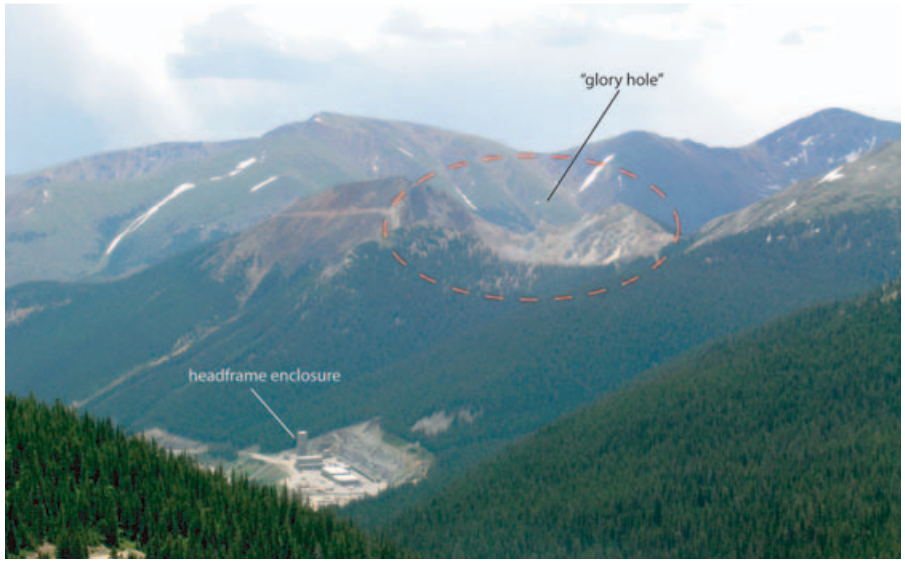

Figure 45. View of the Henderson Mine, Clear Creek County. The headframe for the main shaft is housed in the tall tower in the lower left part of the photo. Red Mountain rises behind the mine. The large "glory hole" (a sinkhole-like feature above the production area) is to the right of the summit of Red Mountain. (Photo by Jim Cappa, CGS.)

Climax Mine, Lake and Summit Counties

The Climax Mine, also owned by Phelps Dodge (now Freeport-McMoRan), was the first major molybdenum mine in the U.S. It is located on the Continental Divide at Fremont Pass between Leadville and Copper Mountain (fig. 46). The mine has been on care-and-maintenance status since 1995, but the recent high price of molybdenum has induced the company to explore the possibility of reopening the mine. In April of 2006, company management announced a feasibility study to investigate re-opening Climax. The pre-feasibility study showed that the mine could produce 20 to 30 million pounds of molybdenum annually and employ 300 workers. The Climax deposit contains 156 million tons of ore grading at 0.19 percent molybdenum, containing more than 500 million pounds of recoverable molybdenum. Estimates of additional reserves indicate more than 570 million tons of ore at 0.16 percent grade. The old facilities are being demolished and would be replaced with new buildings, including a mill that would process 30,000 tons per day of ore. The target production for the Climax Mine would be 24 million pounds of molybdenum per year. The feasibility study is scheduled for completion in August 2007. Management will then make the decision on the re-opening.

Figure 46. The Climax molybdenum mine and mill at Fremont Pass, Lake and Summit Counties. The Mine is currently on care and maintenance status. (Photo by John Keller)

Henderson Underground Science and Engineering Project (HUSEP)

The Henderson Mine is a candidate site for a major program entitled the Deep Underground Science and Engineering Laboratory (DUSEL). The other leading candidate is a similar site—the Homestake Mine in South Dakota. The Henderson Project (termed HUSEP or Henderson Underground Science and Engineering Project)is a consortium of university scientists, engineers, the Climax Molybdenum Company and local communities that was formed to coordinate the proposal and establishment of the DUSEL at Henderson. If realized, the Henderson facility would provide a comprehensive science and engineering program that is expected to result in discoveries with far-reaching impact in physics, geoscience and bioscience. It will also have a substantial impact on the local economy and will become a magnet for prominent scientists from all over the world. The expected lifespan for the DUSEL facility will be at least 30 years and will cost $300 to $400 million for construction and initial experiments. The annual budget is expected to be around $50 million, and about 200 persons will be employed on a permanent basis.

The idea of a DUSEL grew out of the need for scientists in several disciplines to have access to a deep underground laboratory for sophisticated experiments in their respective fields. Physicists require a deep underground location to shield their experiments from bombardment by cosmic rays from space. The cosmic rays interfere with the high sensitivity detectors needed for many experiments. Geoscientists require access to deep underground environments in order to solve questions regarding the deformation of rock, changes in fluid flow and chemistry and other properties that change with depth and pressure. Engineers need access to such environments to develop technology to efficiently and safely produce deep excavations to store fuels and wastes and to possibly sequester CO_2 and other greenhouse gases.

Gold

According to the most recent statistics available, Colorado is the 4th leading gold-producing state behind Nevada, Utah, and Alaska. Total Colorado gold production for 2006 is estimated at 303, 484 ounces, representing a 13 percent decrease from the 2005 production figures. The average annual gold price for 2006 was $610 per ounce, a net value of $185 million. The estimated production comes from two mines—the Cripple Creek and Victor (CC&V) gold mine in Teller County and the Golden Wonder Mine in Hinsdale County. Additional small amounts of gold were probably produced from small placer (gravel) or lode mines that do not publicly disclose production figures. Figure 47 shows Colorado gold production along with the average annual gold price from 1968 to 2006. In May of 2006, gold hit a high of over $720 per ounce, and spent most of the year between $600 and $650 per ounce.

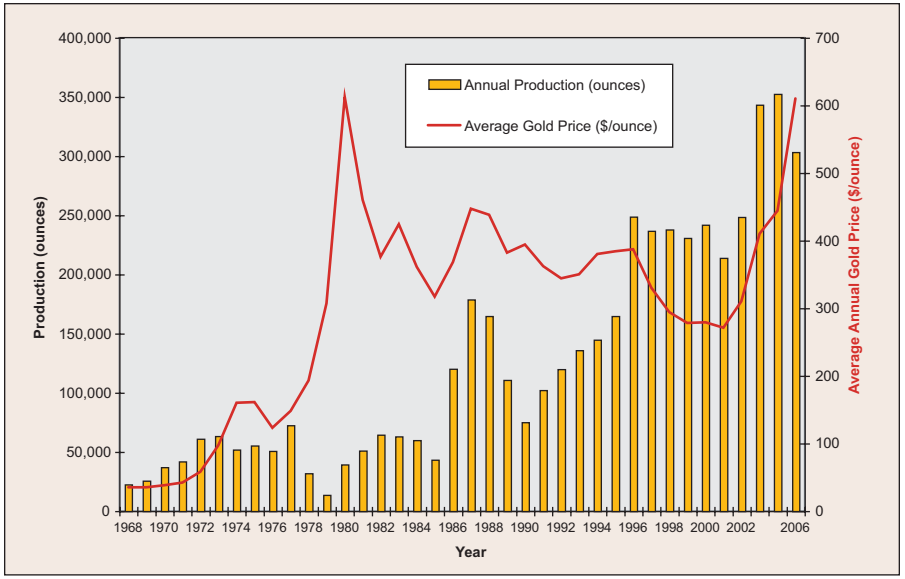

Figure 47. Colorado annual gold production and average annual gold price, 1968–2006. (Kitco.com)

Uses of gold

The best known uses for gold and silver are as jewelry and as investment vehicles as an option to currency. Both metals, however, have a number of industrial applications. Gold possesses superior electrical conductivity and corrosion resistance that makes it important in computer hardware, communications equipment, spacecraft, and jet engines. Gold is also important as a dental filling.

Cripple Creek & Victor Mine, Teller County

The Cripple Creek & Victor Mine (CC&V) is a joint venture between AngloGold Ashanti Ltd., a South African company, and Golden Cycle Gold Corporation of Colorado Springs. The mine (fig. 48) is one of the most productive gold mines in the U.S., producing 283,484 troy ounces of gold from 6 million tons of ore in 2006. This total was down from 329,625 ounces produced in 2005. The gold is produced at the mine in buttons or "dorés" for shipment (fig. 49). Total cash costs of production were $352 per ounce of gold. Based on an average price of gold in 2006, the value of gold produced at the mine was approximately $185 million. Production was down because dry weather resulted in lower through-put of rainwater on the leach cells.

There are three active and two inactive surface mining areas at CC&V. The grade is low but high volume allows profitable production. Mining in 2006 proceeded

Figure 48. Aerial view of the Cripple Creek & Victor Mining Company operations in Teller County. The heap leach pad and State Highway 67 are in the foreground, the open-pit mines are behind and above the pads. The town of Victor is to the right of the mine and Pikes Peak is in the background. (Photo courtesy of AngloAshanti Gold Corp.)

at a rate of 164,000 tons moved per day and 23 million tons of ore were crushed. At the beginning of 2007 the company's stated ore reserve was 142.2 million tons containing 2.33 million ounces of recoverable gold. Those figures represent an average grade of 0.016 ounce per ton with a cutoff grade (minimum mineable grade) of 0.007 ounces per ton.

The company's forecast for 2007 is 308,000 ounces of gold production. 2007 will also be the beginning of a two year feasibility study to extend the mine life, including preliminary engineering and environmental studies and $12 million for exploration.

The Cripple Creek District has produced over 23 million ounces of gold since its discovery and initial development in 1891. The gold mineralization is hosted by veins and breccias within an alkaline volcanic complex of mid-Tertiary age. The mineralized volcanic complex is centered near the intersection of three major rock types of the much older Precambrian basement.

Figure 49. Production at the Cripple Creek & Victor facilities of gold doré buttons produced by CC&V. The buttons weigh 65–70 pounds,and are composed of 65 to 70 percent gold, with the rest silver. The typical weight is around 650 ounces of gold and 200 ounces of silver worth nearly $500,000 each. (Photo courtesy of Cripple Creek and Victor Corp.)

Golden Wonder Mine, Hinsdale County

The Golden Wonder is a small high-grade underground gold mine near Lake City in the San Juan Mountains of Hinsdale County, owned by LKA International of Gig Harbor, Washington. High-grade crushed ore from the mine is trucked in "super sacks" to a facility in Nevada for milling and processing. The Golden Wonder was originally discovered in 1880 and has been worked sporadically since that time. Since modern operations began in 1998, the mine has produced over 120,000 ounces of gold. The mine has produced since January 2000 an average of 21,750 ounces of gold per year with an average grade of 16.23 ounces per ton. The second quarter production in 2006 was 373.6 tons of ore with an astounding average grade of 28.02 ounces per ton, yielding 10,466 ounces of gold. Further exploration drilling has been performed to extend the reserves of the mine.

The Golden Wonder is an epithermal vein system hosted in volcanic rocks of the San Juan volcanic field. The vein system consists of several en echelon quartz veins ranging in width from a few inches to 5.5 feet. Both fracture-fill and replacement textures are present in the veins, and hydrothermal breccia occurs locally. Two main ore assemblages have been identified: gold-bearing chert (chert type), and pyrite-marcasite-sulfosalt (sulfide type). Gold-bearing telluride mineralization is also present, and is commonly very high-grade.

Cash and Rex Mines, Boulder County

Global Minerals, Ltd, of Vancouver, B.C., through its Colorado subsidiary Mount Royale Ventures, LLC, continued development through 2006 of their gold project in the Gold Hill district west of Boulder and began production in March of 2007. The project area is composed of 106 patented and unpatented mineral claims over an area of some 480 acres. Eighteen former mines produced within this area and it has taken 40 years to complete consolidation of the properties in the district. Included is a refurbished mill designed and permitted to process 50 tons of ore per day while planned upgrades will push the capacity to 75 to 100 tons per day. Measured resource of the Cash and Rex mines is 15,948 tons at 1.71 ounces of gold and 14.8 ounces per ton of silver according to the company. The company received permission from the Colorado Division of Reclamation, Mining, and Safety to begin production in the MRV Adit No. 1 (Cash Mine, 3rd Level) in October, 2006. As of March 2007, five stopes were fully developed with four additional stopes planned in areas with known resource. At the time of this report, the mill has produced over 150 pounds of very high grade gravity concentrate and 20 ounces of doré from the gravity concentrate. The first shipment to the smelter occurred on March 19, 2007 (fig. 50). The operation was awarded the 2006 Hardrock Reclamation Award from the Colorado Mined Land Reclamation Board and awarded Senior Participant status with special recognition from the Colorado Mining Association's pollution prevention program in 2006.

Figure 50. Ore cars at the Cash Mine. (Photo courtesy of Mont Royale Ventures, LLC.)

Silver

Silver is currently produced in Colorado only as a byproduct of gold mining at the Cripple Creek and Victor Mine. The value of silver production is very small compared to that of gold because of the price differential between the two noble metals. In 2006, AngloGold Ashanti, Ltd, reported that CC&V produced 127,617 ounces of silver. Based on the annual average silver price for the year of $11.63 per ounce, the gross value of silver produced was $1,484,000. Silver, like gold and most other metals, has been enjoying a price boom over the last four years. Figure 51 shows the average annual price of silver from 1984 to 2006. The price continues to rise, exceeding $14 an ounce in 2006 and early 2007 for the first time in over twenty years.

Uses of silver

Silver possesses the whitest color, the highest optical reflectivity and the highest thermal and electrical conductivity of all metals. These properties give silver importance in such uses as mirrors, electrical and electronic components. Silver serves as an excellent catalyst in oxidation reactions. The primary industrial use of silver was formerly in photography because of the photosensitivity of silver halides. While the development of digital photography has led to the decreased use of silver in photography, that still represents a major end-use of the metal.

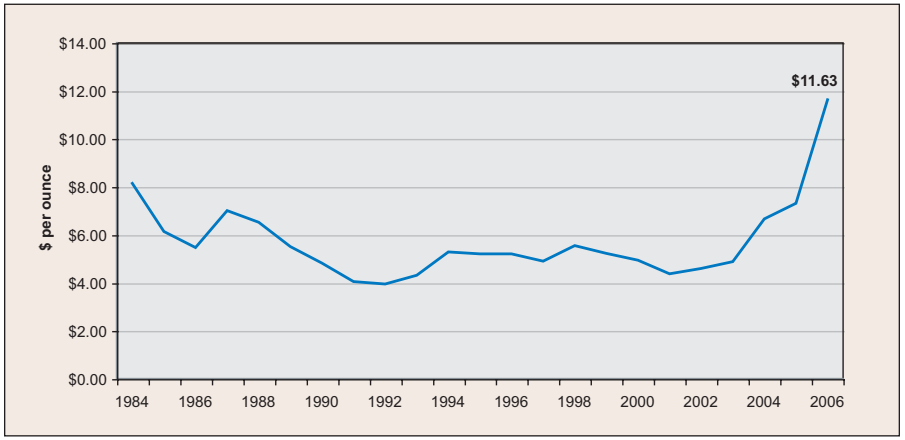

Figure 51. Average annual price of silver from 1984 through 2006, based on London PM fix. (Kitco.com).

Vanadium

Colorado was the only state to produce vanadium ore in 2005, but the cessation of mining at four Cotter Corporation uranium-vanadium mines in Montrose County in November 2005 eliminated that production in 2006. Colorado's uranium deposits in the Four Corners region in the southwestern part of the state are known for their vanadium content. Vanadium prices peaked in 2005 at over $22 per pound, but backed off in 2006 to $8 per pound. This is still considerably higher than the price range seen in the last ten years and at $1 to $2 per pound makes vanadium an attractive by-product of uranium mining in Colorado. At the present time, the scarcity of milling capacity in Colorado has been restraining the development of uranium-vanadium mines. Mills that process uranium ore can separate the vanadium through a second process, so specialized mills are necessary for recovering both uranium and vanadium from Colorado ores. Mill capacity has been lost through recent years when nuclear power generation was out of favor and uranium prices were languishing. The current re-emphasis on nuclear power and, consequently, uranium mining (see *Uranium* section of this report) is spurring the recommissioning and development of new facilities for milling this ore.

Uses of vanadium

Vanadium is a soft, ductile, bright white metal with good corrosion resistance to alkalis, sulfuric and hydrochloric acid, and salt water. It possesses good structural strength and a low fission neutron cross section, making it useful in applications in the nuclear industry. Vanadium is used to produce rust resistant steels and as a carbide stabilizer in high-strength steels. About 80 percent of vanadium now produced is used as ferrovanadium or as a steel additive. Vanadium foil is used as a bonding agent in cladding titanium to steel. Vanadium pentoxide (V_2O_5) is used in ceramics and as a catalyst.

Base Metals

The base metals include lead, zinc and copper. Although Colorado has been a major producer of lead and zinc in the past, there is no current production of these metals. The Leadville district in Lake County was the most prolific base metal district in the state. The last mine to produce base metals in Colorado was the Black Cloud Mine in Leadville, which produced lead, zinc, silver and gold. The Black Cloud shut down in 1999 after 30 years of production. Mines in other areas of Colorado produced base metals also, particularly in the Sawatch Range, the San Juan Mountains and the central Front Range. Prices for base metals have increased dramatically in recent years as demand from developing economies has challenged mining companies to maintain supplies (fig. 52). Additionally, a number of critical and strategic commodities are commonly found associated with base metal deposits—particularly accompanying zinc. For example gallium, germanium and indium are produced as by-products from zinc mining. Recognition of the importance of these materials in modern technology promises to spur further exploration in areas with known former production.

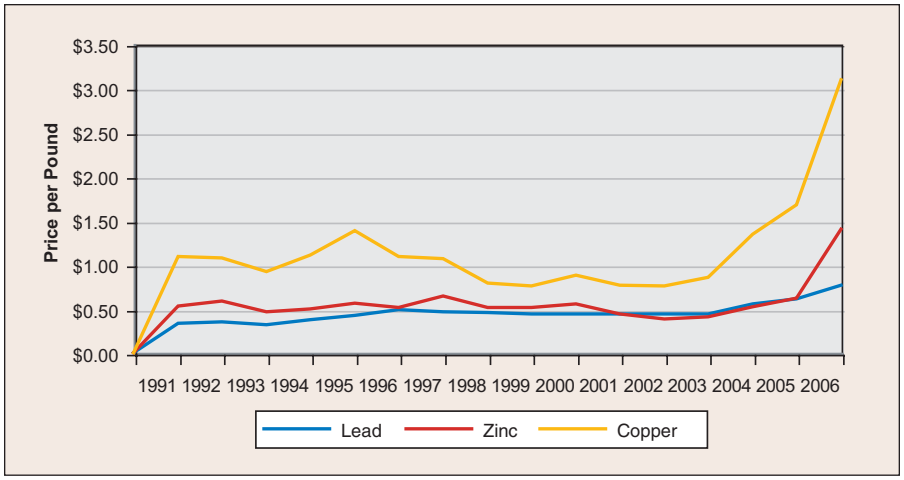

Figure 52. Average annual prices for lead, zinc and copper, 1991 through 2006. (U.S. Geological Survey Mineral Commodity Summaries).

Uses of base metals

The base metals have numerous uses. About 80 percent of lead is used to make batteries. Most copper is used in construction (49 percent), electric and electronic products (20 percent), transportation equipment (11 percent); consumer and general products (11 percent); and industrial machinery and equipment (9 percent). The traditional uses of zinc include anti-corrosion coatings on steel (galvanizing), zinc-base alloys, brass and bronze. Zinc has become increasingly important in paraelectric and thermoelectric materials and in fuel cells for alternative energy production.

METAL EXPLORATION AND DEVELOPMENT NEWS

Bates-Hunter Mine, Gilpin County (gold)

Wits Basin Precious metals, Inc., of Minneapolis, Minnesota, continued exploration and development work on the Bates-Hunter Mine in Central City. The company controls the mine and mill at the site and possesses active mining and water discharge permits to cover an operation of up to 70,000 tons of ore per year. The company believes that the property contains nine mineralized veins. The mine was previously worked to the 800-foot level, while many mines in the area were productive to levels greater than 2,000 feet. The company has continued to dewater the mine and will initiate an underground drilling program designed to characterize the ore to greater depths when dewatering is finished.

In January 2007, the company announced that 25 percent of a planned 8,000-foot surface drilling program has been completed at the property. Previous drilling in the 1990s confirmed grades of 0.48 ounces per ton over 10-foot widths. Workings at the 800-foot level show that the veins continue to depth. The company feels that any extension of the productive ore zone to the 2000-foot level could host more than a million ounces of gold in the Bates vein system outside the historically mined stopes.

Caribou Consolidated Project, Boulder County (gold, silver, base metals)

The Caribou Consolidated Project near Nederland is focused on defining a large deposit from a property that has been put together from various patented claims, unpatented claims and operational rights to various properties over 2,205 acres over the last 34 years. The owner, Calais Resources, Inc., has completed over 140,000 feet of core drilling and published estimates of over 400,000 ounces of gold and 12.5 million ounces of silver identified at the property. In 2007, emphasis is on completion of various permitting actions. Tom Hendricks, Vice President of Exploration and Corporate Development at Calais, continues to provide educational tours and lectures about the mining project and the importance of good environmental stewardship to interested groups. Mr. Hendricks has 35 years of working experience in the Caribou Mining District.

Little Hope Mine, Teller County (gold)

Minerex Corporation of Illinois received a state permit and the proper permits from Teller County to begin mining the small underground mine north of Cripple Creek. No significant activity occurred in 2006.

Old Idaho and Mayday Mine, La Plata County (gold)

Wildcat Mining Company of San Diego has applied for a permit for a small mine and mill on the site of the Old Idaho Mine in the old California Mining District northwest of Durango. The plan is to refurbish and re-equip the Idaho mill and use that for ore removed from the Mayday and Old Idaho mines.

Lucky Jack Mine, Gunnison County (molybdenum)

The Lucky Jack property consists of some 25 patented mining claims and 520 unpatented claims comprising some 5,400 acres (8 square miles) located 5 miles west of Crested Butte. The property, formerly known as the Mount Emmons prospect, was initially discovered by Amax in 1974 on leases owned by U.S. Energy Corp. Amax delineated a large ore body at the site reportedly containing approximately 155 million tons of mineralization averaging 0.44 percent molybdenite. Amax progressed toward mine development including the drilling of nearly 200,000 feet of core, developing a 4,400-foot drift, and constructing a water treatment

plant on the property. In 2006, the property was re-acquired by U.S. Energy Corp. and Crested Corporation and renamed the Lucky Jack prospect.

In 2007, the company will be working on operations plans for all aspects of the mine. According to George Gillespie, of Crested Corp., the current plan involves mining with a paced backfill system using longhole stoping (working a steplike part of a mine where the ore is being extracted). The goal is to have the plan of operations complete sometime in late summer 2007, a feasibility study for late 2008, and an environmental impact statement by late 2010. Mill construction would begin in the summer of 2011 with mine and mill operational by 2013.

Cashin Deposit, Montrose County (copper)

The Cashin deposit is a sandstone-hosted copper prospect near the Colorado–Utah border that is currently held by Constellation Copper Corporation. If it is developed, Cashin would be a satellite operation to Constellation's Lisbon Valley Mine, located 15 miles southwest in San Juan County, Utah. The Lisbon Valley Mine and processing facilities began copper production in 2006. The Cashin deposit could add several years of copper production to the Lisbon Valley operation. According to a company spokesman, "Constellation is evaluating the technical and economic merits of various options for exploiting the Cashin deposit. Our intention is to transport any ore to our existing Lisbon Valley operation in Utah…We are comfortable with our technical understanding of the *in-situ* grade, mining and metallurgical aspects of the deposit. Transportation options, which will have a major impact on costs, and hence ultimate extraction, require additional trade-off studies."

Using a conservative copper price of $1.25 per pound, Constellation's consultants have estimated that Cashin contains 5.7 million tons of proven and probable ore grading 0.547 percent copper and containing 62.4 million pounds of copper. As this report is prepared, copper is trading at around $2.50 per pound.

Copper was originally discovered in the Cashin area in 1896 and was mined from 1899 to the 1950s. Mineralization consists primarily of malachite and azurite. Chalcocite, neotocite, and chrysocolla are also present. Native copper (and some native silver) was occasionally found in high-grade portions of the historic mine. Copper mineralization at Cashin is hosted by the Wingate Sandstone of Triassic age.

INDUSTRIAL MINERALS AND CONSTRUCTION MATERIALS

Important industrial minerals and construction materials currently being produced in Colorado include sand, gravel, crushed stone, silica sand, dimension and decorative stone, cement, clay, gypsum, sodium bicarbonate, peat, and helium. Total value for all industrial minerals and construction materials produced in Colorado in 2006 is estimated to be over $593 million. This is an increase of 2.8 percent over the 2005 revised total of nearly $577 million.

Construction Sand, Gravel, and Crushed Stone

Colorado produced an estimated 63.6 million tons of aggregate in 2006 and ranked 9th in the nation for sand and gravel production. Leading aggregate producers in the state include Lafarge and Aggregate Industries (table 20). The total value of Colorado aggregate was $388.7 million, which is 5.3 percent more than the 2005 value of $369 million. Sand and gravel represented 77 percent of Colorado's total aggregate production in 2006. Production of sand and gravel totaled 48.6 million tons, down 1.4 percent from last year's revised production of 49.3 million tons. Average price per ton of sand and gravel in 2006 was $5.97 (fig. 53). Crushed stone production increased by 2.6 percent from 14.3 million tons in 2005 (revised) to 14.7 million tons in 2006 (estimated). Average unit value for crushed stone was $6.71 per ton (fig. 54). Forty new sand and gravel and crushed stone mining permits were issued in Colorado during 2006.

The top uses for sand and gravel are concrete aggregate, road base and coverings, construction fill, and asphaltic concrete aggregate. Although the use of sand and gravel predominates in Colorado (77 percent of total aggregate production), nationally, the use of crushed stone as an alternative to sand and gravel has been gaining momentum since the mid-1980s (fig. 55). Crushed stone quarries typically operate within a smaller footprint (fig. 56) and can be located further from

Table 20. There are a total of 1,124 sand and gravel operations in Colorado with active permits. Listed below are the companies that hold five or more active permits (not including state/county/city-owned operations) (Division of Reclamation, Mining, and Safety, 2007).

Rank	Permittee Name	Number of Pits
1.	Lafarge West, Inc.	51
2.	Aggregate Industries, West Central Region, Inc.	21
3.	Carder, Inc	13
4.	Grand Junction Pipe & Supply Co.	11
5.	Coulson Excavating Co.	9
6.	Elam Construction, Inc.	9
7.	Oldcastle SW Group/Four Corners Materials	9
8.	Valco, Inc.	9
9.	Western Gravel, Inc.	9
10.	Connell Resources, Inc.	7
11.	Hall-Irwin Corp.	7
12.	Pioneer Sand Co.	7
13.	Varra Companies, Inc.	7
14.	Continental Materials Corp.	6
15.	Hard Rock Paving & Redi-Mix, Inc.	6
16.	Parkerson Construction Co.	6
17.	Ace West Trucking, Inc	5
18.	Fremont Paving & Redi-Mix, Inc.	5
19.	Southway Construction Co.	5
	Total	**202**

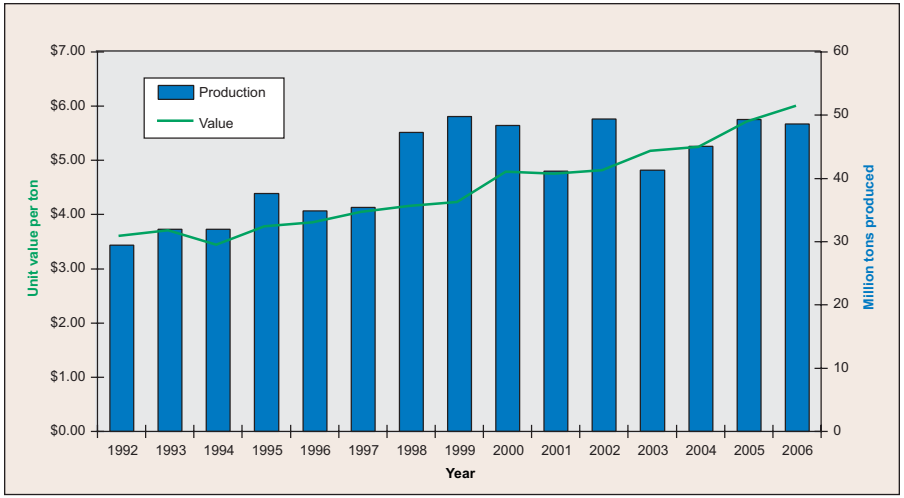

Figure 53. Production and unit value for sand and gravel in Colorado, 1992–2006 (U.S. Geological Survey, 2006 data estimated).

high-density urban areas and scenic and environmentally contentious river valleys. This makes it far easier to obtain a permit. Although higher operating costs equate to higher prices for crushed aggregate, the cost differential is slowly decreasing due to escalating conflict over environmental and land use issues associated with sand and gravel operations.

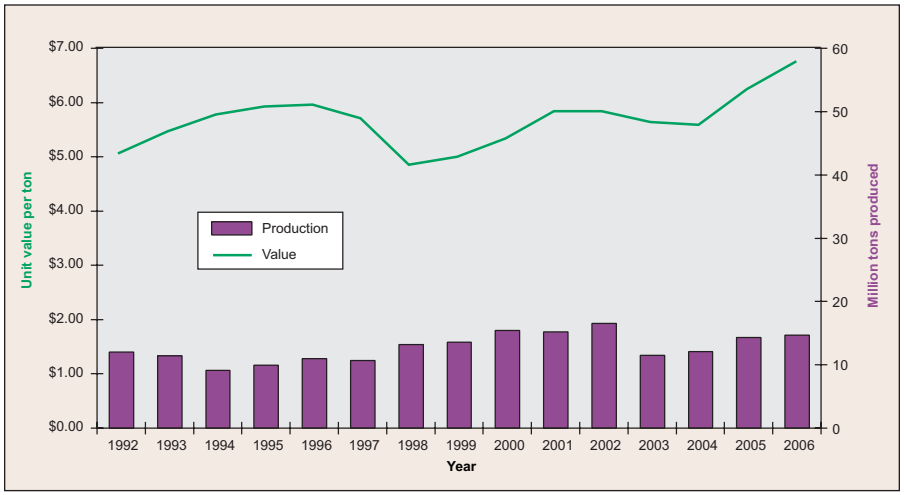

Figure 54. Production and unit value for crushed stone in Colorado, 1992–2006 (U.S. Geological Survey, 2006 data estimated).

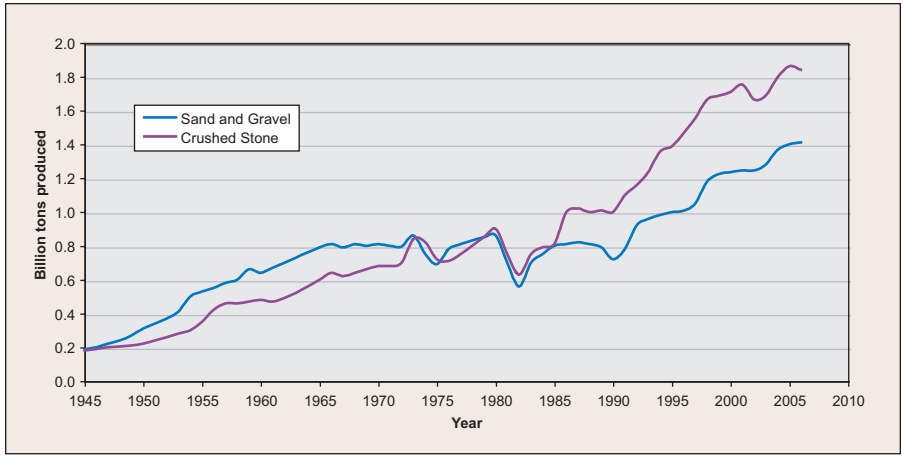

Figure 55. Production of sand and gravel and crushed stone nationwide, 1945–2006 (U.S. Geological Survey, 2006 data estimated). Note that crushed stone aggregate production overtook sand and gravel production in the mid-1980s. However, in Colorado, the majority (77 percent) of our aggregate is still derived from sand and gravel.

Figure 56. Precambrian metamorphic and granitic rocks are quarried at Aggregate Industries' crushed stone operation near the town of Morrison. View is to south (photo courtesy of Aggregate Industries).

Industrial Sand and Gravel

Colorado's leading industrial sand company is the Ohio-based Oglebay Norton Company. The local division office, Oglebay Norton Industrial Sands (ONIS), is located in Colorado Springs. ONIS markets "Colorado Silica Sand," specialty industrial sand that is used primarily as filter media for water purification plants and as a construction material, largely for stucco. Some of their smaller markets include hydraulic fracturing material for oil and gas drilling, gravel packs around water wells, and other applications where roundness, permeability, and strength are important parameters. Additionally, the sand is used as a landscaping material. The majority of product is exported outside of Colorado. Previously, ONIS extracted (essentially recycled) its silica sand from waste material cut from new developments where much of the surface cover is removed or scraped off before construction begins. Currently, the Company has established a captive reserve for feedstock located within Colorado to ensure an uninterrupted, long-term supply of feedstock to the operation.

Dimension and Decorative Stone

Dimension stones are quarried slabs or blocks of attractive rock that are used for decorative construction, facing panels, flagstone, sculptures and monuments, and many other projects requiring large, competent masses of stone. Many dimension stone producers may also crush and market some of their stone for landscaping purposes. Colorado produced an estimated 20 million tons of dimension stone in 2006 with an estimated value of $2.5 million. This is an 11 percent increase over the revised 2005 production figure of 18 million tons. The principal Colorado dimension stones include marble, sandstone, granite, and rhyolite.

Decorative stone has become a more important part of the Colorado minerals industry in recent years. Both crushed rock and whole boulders are used. Granite, gneiss, sandstone, volcanic rock, obsidian, marble, and quartz pegmatite are some of the rock types currently being mined in the state for decorative use. Natural boulders that have a covering of lichen on them are commonly known as "moss rock" in the landscaping industry. Usually, the larger the percentage of the rock covered with the colorful lichen, the more valuable it is. Numerous small decorative stone mines and quarries are located throughout Colorado. No specific production figures are available for statewide decorative stone production.

Arkins Park Stone, Larimer County

Arkins Park Stone Corporation employs about 40 people and operates three quarries near the town of Masonville. Annual production typically averages just over 8,000 tons. The company produces buff (light pinkish-brown) sandstone as well as "Berthoud Pink" and "Berthoud Sunset" sandstone from the Permian Lyons Sandstone. Approximately 80 percent of the product is sold or used in Colorado. Much of the stone is used as flagstone and facing in the construction of buildings. Recently, the company also began producing rip-rap for commercial uses such as riverbed linings, dams, and bridge abutments.

Figure 57. Workers hand-trim flagstone blocks at B&B Stoneworks' quarry near Lyons. The flagstone is derived from the Permian-age Lyons Sandstone.

BB Stoneworks, Inc., Larimer County

BB Stoneworks, Inc. was incorporated in 1999 and now does business as Lyons Sandstone—after the Permian-age sandstone that is mined at the quarry. The quarry operates year-round as weather permits and employs up to 45 workers during the warmer months. The Lyons operation is primarily a flagstone and dimension stone quarry, but some crushed stone and rip rap material is also produced. The Lyons Sandstone is one of the hardest sandstones in the world and has a very low absorption. The stone is quarried by hand using steel wedges, sledge hammers and pry bars (fig. 57). In 2006, approximately 11,000 tons were sold. Much of the stone is used in Colorado, but the company is actively pursuing other markets across the U.S. and Canada.

Colorado Quarries, Custer, Chaffee, Fremont, Teller Counties

Colorado Quarries operates several quarry operations that produce decorative, pre-cast, and landscape stone. In 2006, they produced 36,206 tons of stone. Marketed products include *White Quartzite* from Howard; *Ruby Spar, RG Rose Quartz,* and *Flamingo Quartz* from near Cañon City; *Green* and *Indian Rhyolite* and *Black Obsidian* from near Westcliffe, *Red Granite* from near Guffey; and *Gray Granite* from near Texas Creek. These materials are used principally in the landscape industry as decorative boulders, building stone, and crushed stone. Their materials are also

used in the pre-cast market (panels on buildings and other structures). Standard stone mining equipment is used at all quarries. Stone from Colorado Quarries has been used on the Pepsi Center and Colorado Convention Center in Denver and the Colorado Springs Airport and U.S. Air Force Academy in Colorado Springs.

Yule Quarry, Gunnison County

Colorado Stone Quarries, a subsidiary of Polycor, Inc. of Quebec, Canada owns and operates the Yule Marble Quarry. Polycor operates a number of marble and granite quarries in North America, has a number of fabricating facilities, and has a substantial presence in international stone markets. Some Yule marble is used for sculpting, although the majority of stone is now being made into slab and tile for international sales. Production data for 2006 were not available at the time of this report. Approximately 99 percent of production is exported outside of Colorado, with destinations including Italy, Indonesia, China, India, Quebec, and Georgia. Yule Marble is the official state rock of Colorado.

Other Stone Operations

The Colorado Red Rose Quarry in Larimer County produces blocks of red granite for use as countertops and monuments. Alabaster is quarried from the Permian Lykins Formation at a small mine near Fort Collins by Colorado Alabaster Supply. Their alabaster is used mainly for sculpting and is marketed both locally and nationwide. The White Banks Mine in Pitkin County also produces alabaster, as well as dark-colored marble, and quartz. The Eocene-age Wall Mountain Tuff, known in industry as Castle Rock rhyolite, is quarried by the Ames Construction Company near the town of Castle Rock. The Castle Concrete Company operates the Table Mountain Quarry in Fremont County and produces 150,000 tons of hard, dense, high-silica Dakota Sandstone annually for use as riprap, road base, aggregate, and dimension stone. Numerous other small operations quarry various sandstone units throughout the state.

Cement

According to the Portland Cement Association (PCA), cement consumption rose 0.5 percent nation wide in 2006; forecasts indicate an even smaller increase in consumption during 2007. An ongoing slump in residential construction (2006 to 2007), caused by softening of the market and higher inflation and interest rates, has not been offset by non-residential construction as was hoped. In 2005, at least 32 states, including Colorado, experienced tight cement supplies; sluggish cement consumption in 2006 has helped to alleviate these tight market demands.

Cemex, Inc., Boulder County

Portland and masonry cement are produced at the Cemex, Inc. mine and processing plant near Lyons. The plant uses the dry processing method and employs about 100 people. Cement production in 2006 was 459,595 tons, most of which was utilized in the Front Range urban corridor. Cement ingredients (limestone and shale) are mined locally from the Niobrara Formation and the overlying Pierre Shale.

GCC Rio Grande, Inc., Pueblo County

GCC Rio Grande, Inc., a subsidiary of Grupo Cementos de Chihuahua, has been planning and permitting a new cement plant in Pueblo during the past several years. Construction of the plant and mining facilities began in mid-2005 and is continuing at a good pace. The raw materials storage building and structural framework for the limestone storage dome and pre-heater tower (about 300 feet high) have all been built. Nearly 100 administrative and plant employees have been hired and are currently undergoing training. No official start up date has been set. The mine and processing plant is expected to produce about one million tons of cement per year. The Fort Hays Member of the Niobrara Formation will be mined for the main cement ingredients.

Holcim (US), Inc., Fremont County

The Portland Plant near Florence is operated by Holcim (US), Inc. (fig. 58). In 2006, the plant employed about 180 people and produced about 1.8 million tons of cement. The majority of their product is used in the metropolitan Denver area and throughout Colorado, although some cement is also distributed to neighboring states such as New Mexico, Wyoming, Kansas, and Nebraska. Limestone from the Fort Hays Member of the Niobrara Formation of Upper Cretaceous age is mined by Holcim as the principle raw ingredient for their cement. The Codell Sandstone, also Upper Cretaceous age, is mined for use as a silica additive. Most of the company's gypsum is imported from Oklahoma; some gypsum is produced as a byproduct of Holcim's lime calcining plant.

Figure 58. Primary crusher (foreground) and blending hall (at distance) at Holcim's Portland cement plant in Florence. The long belt connecting the two is necessitated to ensure proper blending of limestone, shale, and sandstone into a clinker mix in the blending hall.

Clay and Shale

The majority of the clay mined in Colorado is common clay, which is used mainly to make bricks and tiles or in the manufacture of cement and lightweight aggregate. Common clay is mined primarily in eastern Colorado, especially near the Front Range in Jefferson, Elbert, Douglas, El Paso, Pueblo, and Fremont counties. In 2006, Colorado clay mines produced an estimated 279,000 tons of clay valued at over $1.6 million. This represents a slight decrease of about 1.9 percent from the 2005 production total of just over 284,000 tons (fig. 59). In eastern Colorado, clay is mined principally from three formations: the Laramie Formation (Upper Cretaceous), the Dakota Sandstone (Lower Cretaceous), and the Dawson Formation (Upper Cretaceous to Tertiary). Elsewhere in the state, clay deposits within the Lykins, Morrison, Benton, Niobrara, Mesaverde, and Vermejo Formations (ranging in age from Triassic to Cretaceous) have also been exploited.

Higher quality clays have also been produced from the Dakota and Dawson Formations. Both formations locally contain resources of refractory clay, which is used in the manufacture of refractory ware, such as crucibles and high temperature firebricks for kilns. Current market demands have not warranted active mining of these deposits. Additionally, bentonite clay layers are found in altered volcanic ash in Fremont County, and locally in the Jurassic Morrison Formation and the Cretaceous Pierre Shale. Bentonite is frequently used as an absorbent (such as in kitty litter or to clean up hazardous fluid spills) and as a containment barrier (such as in clay liners for landfills). Colorado typically produces approximately 1,500 to 5,000 tons of bentonite annually, although, actual production and value data for bentonite is unavailable.

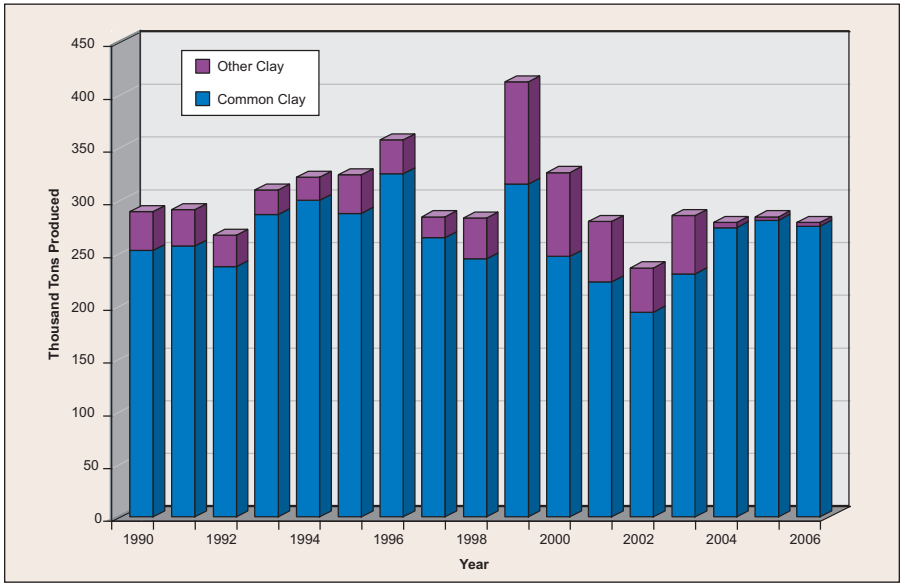

Figure 59. Total clay production in Colorado decreased slightly from 2005 to 2006 (U.S. Geological Survey, 2006 data estimated). Most of the clay mined in Colorado is *common clay*, which is used primarily for making bricks. Other clays may include bentonite, refractory clay, or other specialty clays.

Acme Brick

The Acme Brick Company's Denver Plant employs 75 people. They mine approximately 110,000 tons of clay and manufacture about 60 million bricks per year. Most of their product is sold outside of Colorado. Acme owns and operates five clay mines in Jefferson, Elbert, and Douglas counties: two mines produce clay from the Cretaceous Dakota Group, two produce from the lower Dawson (Denver) Formation (Paleocene), and one produces from the upper Dawson Formation (Eocene). In 2008, the company plans to open a new clay mine in Elbert County which will produce from the lower Dawson Formation. Standard open-pit mining methods are utilized at all mines.

Lakewood Brick and Tile Co.

Lakewood Brick owns and operates two clay pits, Doughty and Church, in Jefferson County near Rocky Flats. In 2006, they mined over 23,000 tons of clay from these two pits. Additionally, Lakewood Brick supplements its stockpiles with clay purchased from other local suppliers. At their brick processing facility, 37 employees manufacture an average of 17 million bricks per year. Half of this production remains in Colorado, while the remainder is exported to other states. Recently Lakewood Brick opened a new showroom in Lakewood and merged their sales division with Summit Brick in Pueblo forming Summit-Lakewood Brick Sales.

Robinson Brick Co.

Robinson Brick operates 14 clay mines in five Colorado counties including: Jefferson, Douglas, El Paso, Elbert, and Pueblo. These mines produce from the Dakota Formation, Benton Shale, Fox Hill Sandstone, Laramie Formation, and Dawson Formation—all of Cretaceous age. Robinson Brick produces approximately 180,000 tons of clay annually and employs about 600 people in one brick manufacturing plant, two block manufacturing plants, one stone quarry, and 19 showroom locations across the country in seven states: Colorado, Utah, Wyoming, Oklahoma, Nebraska, Illinois and Montana. There are also over 200 distributors of Robinson Brick Company products throughout the United States and Canada. Robinson Brick offers a full-size modular brick, as well as Old Brick Originals Thinbrick. All of the standard brick that is manufactured is FBX+ grade and is ISO 9001 registered. Old Brick Originals is real brick that is cut and packaged as Thinbrick veneer. Robinson Brick Company produces approximately 95 million bricks per year.

Summit Brick and Tile Co.

In 2006, approximately 60,000 tons of clay were produced from 10 Summit Brick mines in El Paso, Fremont, and Pueblo Counties. Approximately 27 million bricks are manufactured annually at the plant, about 35 percent of which are sold within Colorado and the remainder of which are shipped throughout the U.S. Summit's mines and plant employ approximately 85 people. One of the Summit mines produces common clay for brick manufacturing from the Cretaceous Pierre Shale. Three other mines produce fire clays from the Cretaceous Dakota Group, which are used to manufacture white brick. Summit's red-burning clays are derived from the Morrison Formation and from the contact zone between Precambrian Pikes Peak Granite and the Pennsylvanian Fountain Formation. Standard open-pit mining techniques are used at all the mines.

TXI

The Pierre Shale in northern Jefferson County is mined by TXI for use as lightweight aggregate. The raw shale is kiln-fired to drive off excess water and force expansion of clay mineral molecules. The resulting product is light-weight and low in density. Lightweight aggregate is used in place of regular sand, gravel, or crushed stone in applications where excessive weight is undesirable, such as floors and walls in multi-story buildings. Cinder blocks are commonly made with lightweight aggregate. TXI employs 43 people at their mine and processing facility. In 2006, approximately 398,000 tons of shale were mined to produce 369,000 cubic yards of lightweight aggregate. Roughly half of their finished product is sold within Colorado; the remainder is sold to other western states, particularly California.

Gypsum

Most gypsum production goes towards the manufacture of wallboard and plaster products. Gypsum is also used as a cement ingredient, as a soil conditioner, and in other industrial uses such as glassmaking and smelting. The principal producer of gypsum in Colorado is American Gypsum. Colorado Lien and a few other small operations produce gypsum for cement or soil conditioners.

American Gypsum, Eagle County

The American Gypsum mine and wallboard plant, located near the town of Gypsum, produced 612,000 tons of gypsum in 2006. Approximately 600 million square feet of wallboard are manufactured annually at the plant. About 50 percent of the wallboard goes to the Colorado construction industry, and the remainder is marketed throughout the U.S. The gypsum is excavated from evaporite deposits in the Pennsylvanian Eagle Valley Evaporite using a surface (or pavement) grinder. The company is in the process of developing a new mining area northeast of the current site. Over a span of a few years, mining will shift to the new site as reserves are depleted at the original site. The future mining area ensures that the wallboard plant can operate for at least another 20 years. The mine and plant employ approximately 125 people.

Colorado Lien, Larimer County

Colorado Lien, subsidiary of Pete Lien & Sons, Inc. of South Dakota, produces gypsum from the Munroe Quarry north of Fort Collins near Livermore. Gypsum is extracted from the Permian Lykins Formation using a portable crusher. Annual production averages about 50,000 tons. The majority of the material quarried is sold within the state to the cement industry. The plant employs approximately 10 people.

Sodium Bicarbonate and Soda Ash (Nahcolite)

The principal uses of sodium bicarbonate are for human food products and animal feed. Other uses may include cleaning products, pharmaceuticals, chemicals, water treatment, and a multitude of other products.

Natural Soda, Inc., Rio Blanco County

Natural Soda Inc. uses solution mining to recover naturally occurring sodium bicarbonate from nahcolite on its Bureau of Land Management (BLM) leases in the Piceance Basin in northwest Colorado. In 2006, the solution mine and recovery plant produced 98,739 short tons of sodium bicarbonate, a 17 percent increase

Figure 60. Aerial view of Natural Soda Inc's sodium bicarbonate plant in Rio Blanco County. Pipes that transport nahcolite-bearing solution from wells to the plant can be seen in the upper left. (Photo courtesy of Natural Soda, Inc.)

over the 84,304 tons produced in 2005. The facility has a permitted production capacity of 125,000 tons per year. Both food-grade (baking soda) and industrial-grade sodium bicarbonate are produced at the plant (fig. 60). Prices for sodium bicarbonate have increased because of energy price increases; prices ranged from $110 to $200 per short ton (FOB) in 2006. Using these figures, a minimum estimate of production value for Colorado's sodium bicarbonate in 2006 is $10.9 million. Natural Soda, Inc. maintained production in 2006. Plans for 2007 include the installation of a new production well.

High-grade nahcolite (>80 percent) is recovered from the "Boise bed" of the Green River Formation. Dissolution of the nahcolite is through drill holes along the base of the Boise bed. The nahcolite-bearing solution is pumped to the surface via separate recovery wells. Natural Soda also owns the Rock School lease, an undeveloped nahcolite property nearby. The two properties, both leased from the BLM, together comprise over 9,500 acres in the Piceance Creek Basin. These leases contain *in situ* nahcolite resources estimated to exceed 4 billion tons.

American Soda LLP, Garfield County

The American Soda facility owned by Solvay Chemicals, Inc., produces sodium bicarbonate using soda ash feedstock from Solvay's trona processing facility near Green River, Wyoming. The soda ash is transported by rail to the American Soda plant in Parachute. From 2001 to 2004, American Soda also produced soda ash as sodium bicarbonate from nahcolite extracted from the Green River Formation in Rio Blanco County, Colorado. The mining operation is currently in a "temporary abandonment" status and production has been curtailed for over a year. Natural gas was used to heat injection water to dissolve the nahcolite, but natural gas prices have been too high to allow profitable mining. The company controls over 7,000 acres of nahcolite mineral leases in Rio Blanco County on land managed by the BLM.

Peat

Peat is a mixture of decomposed organic matter, the quality of which is determined by the level of decay. Sphagnum moss is the least decomposed and highest quality. Hypnum moss, reed-sedge, and humus are progressively more decomposed and of decreasing quality. Peat promotes plant growth and has widespread use as a soil additive in the agricultural and horticultural industries. It can also be used to filter or absorb contaminated water or hazardous material spills. There are three active permitted peat mines in Colorado, although only one of the mines is currently producing. This small, intermittent operation near Alamosa produces humus-grade peat to fill local landscaping needs. The peat is extracted from a dry bog as opposed to wetland areas typical of other worldwide peat resources. Colorado demand for peat is met primarily through imports, mostly from Canada.

GEM AND SPECIMEN MINERALS

The varied geological environments of Colorado provide a large variety of gemstones and specimen-quality minerals. Small mining operations periodically produce commercial quantities of stones, but most of the activity is by amateur collectors. Notable deposits are often operated by weekend miners who provide quality material to the gem and mineral trade.

The U.S. Geological Survey estimates that Colorado produced gem and specimen minerals worth $358,000 in 2006, roughly equal to the same total estimated for 2005. Colorado ranks 9th among the gem-producing states. Because of the nature of the commerce in gems and specimen minerals, it is impossible to accurately estimate the total value. Anecdotal evidence indicates that the actual value may be somewhat greater; gem and mineral shows in the state generate several million dollars in transactions each year, but there are no data indicating how much of the trade is attributable to specimens from Colorado.

Colorado is famous for several specific types of gemstones and specimen minerals. Rhodochrosite (the official State mineral) from the Sweet Home Mine in Park County is probably the most famous, although aquamarine (the official State gem) from Mount Antero in Chaffee County is known around the world. Colorado minerals that generate a high dollar volume include cryptocrystalline quartz. In its various forms, this mineral is known as carnelian, chalcedony, onyx, sardonyx, chrysoprase, agate, jasper, petrified wood and many others. It is found in many locations around the state, with petrified (agatized) wood occurrences in Arapahoe, Douglas, Elbert, and El Paso counties.

Table 21. Partial listing of gemstones and specimen-quality minerals found in Colorado.

Specimen mineral/ gemstone name	Some Colorado occurrences	Comments
Aquamarine	Mount Antero, Chaffee County	Colorado's official State Gemstone. Significant new discoveries on Mt. Antero recently. Found in cavities in the granite.
Rhodochrosite	Rhodochrosite is found in at least 17 counties in Colorado. The best-known locations include: Sweet Home Mine, Park County; Sunnyside Mine, San Juan County; Moose Mine, Gilpin County; Urad Mine, Clear Creek County.	Colorado's official State Mineral. The Sweet Home Mine produced the finest red transparent specimens in the world. The mine closed in 2004.
Diamond	State Line district, Larimer County	The Kelsey Lake diamond mine operated sporadically from the mid-1990s until 2002. Now reclaimed, it was the only commercial diamond mine in the U.S.
Amazonite	Crystal Peak area, Park and Teller Counties; Harris Park, Park County; Cameron Cone, Specimen Rock, and Crystal Park in El Paso County.	Spectacular blue-green feldspar occurs in miarolitic cavities in Pikes Peak Granite. Often found with smoky quartz.
Topaz	Spruce Grove campground area, Jefferson County; Crystal Park, El Paso County; Specimen Rock, El Paso County; Crystal Peak & Glen Cove areas, Teller County; Ruby Mountain, Chaffee County; Mt. Antero, Chaffee County, Pilot Peak, Park County.	Large quantities have been cut into gems and many others are on display around the world. Found in miarolitic cavities in granite or rhyolite.
Smoky quartz	Lake George and Florissant area, Park and Teller CountiesHarris Park, Park County; Wigwam Creek, Jefferson County; Specimen and Sentinal Rocks, Teller County.	Often found in association with amazonite in miarolitic cavities in Pikes Peak Granite.
Turquoise	Hall Mine near Villa Grove, Saguache County; Cripple Creek area, Teller County; King Mine, Conejos County; Turquoise Chief Mine, Lake County.	Colorado was at one time second only to Nevada in turquoise production. Currently being mined in the Cripple Creek area.
Cryptocrystalline Quartz	Del Norte area, Saguache County; Specimen Mountain, Larimer County; Klouse in Weld County; Opal Hill & The Redlands, Mesa County;	DelNorte plume agate is famous; agatized (petrified) wood occurs in many locations in East Central Colorado.
Peridot (gem-quality olivine)	Badger Creek area, Park and Fremont Counties.	This is a relatively recent discovery (1990s). Small pieces of gem-grade peridot are present in Tertiary-age basalt.

NON-ENERGY GASES

Carbon Dioxide

It is estimated that Colorado will produce 373 Bcf of naturally-occurring carbon dioxide (CO_2) in 2006, an increase of 3.3 percent from the 361 Bcf produced in 2005 (fig. 61). The total value of this production is estimated at $290 million for 2006 based on an average price of $0.78 per Mcf (table 22) and would represent a 21 percent increase from the $241 million for 2005 (Colorado Oil and Gas Conservation Commission, 2007).

Montezuma County sold 238 Bcf or 95 percent of the CO_2 production reported for 2006. The Mississippian Leadville Limestone at the McElmo Dome field supplies CO_2 for enhanced oil recovery applications in the Permian Basin. Dike Mountain and Sheep Mountain fields in the northwestern part of the Raton Basin in Huerfano County produced 4.7 percent of the state's reported CO_2. As with the CO_2 produced from McElmo Dome, Raton Basin CO_2 is supplied to the Permian Basin.

McCallum and McCallum South fields in the northeast part of the North Park Basin in Jackson County contributed less than 0.2 percent of the state's

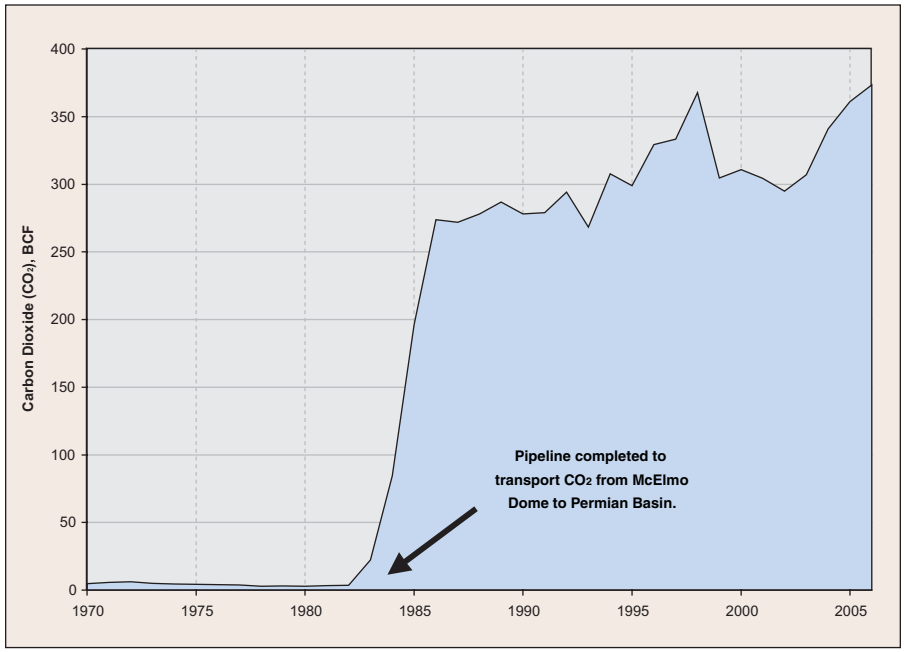

Figure 61. Carbon dioxide production, annual data for 1960–2006 (Colorado Oil and Gas Conservation Commission, 2007).

total carbon dioxide production in 2006. North Park CO_2 is used welding gases, the manufacture of dry ice, and the food and beverage industry. For the first time, a very small volume of recycled CO_2 production is reported for the Rangely field in Rio Blanco County (table 22).

Table 22. Volume of CO2 Production Sold by County and Value for 2006

County	Source	Billion cubic feet Sold(1)	Value in Million $(2)
Montezuma	McElmo Dome	237.87	278.94
Huerfano	Sheep Mountain	11.67	10.34
Jackson	McCallum	0.41	0.38
Rio Blanco	Rangely	0.014	0.02
Total		**249.96**	**289.67**

(1) Production volumes for 2006 are incomplete. (2) Value is determined by annualizing the first six months' reported production and utilizing $0.78 per thousand cubic feet (Colorado Oil and Gas Conservation Commission, 2007).

Helium

Grade-A helium is produced at the Ladder Creek Plant in Cheyenne Wells, Cheyenne County, operated by DCP NGL Services, a wholly-owned subsidiary of DCP Midstream, LLC. The Ladder Creek plant was formerly owned and operated by Duke Energy Field Services, which is now DCP Midstream. Helium is separated from natural gas by liquefying the product at about minus 458 degrees Fahrenheit. Helium is used as a coolant in cryogenic applications, for pressurizing and purging, as a welding cover gas, for controlled atmospheres, leak detection and breathing mixtures. According to the BLM the industry experienced shortages in 2006 and anticipates continued shortages for 2007. Prices for Grade-A gaseous helium from private industry suppliers were estimated by the U.S. Geological Survey at $80 to $85 per thousand cubic feet. The Ladder Creek plant produced 92.5 million cubic feet of helium from local sources in 2005 and also produced product from material trucked in from other locations. (Figures are not yet available for 2006.) Nationwide consumption of grade-A helium was estimated by the U.S. Geological Survey to be 79 million cubic meters in 2006, down from 81.6 million cubic meters in 2005.

INFORMATION SOURCES AND ACKNOWLEDGEMENTS

The Colorado Geological Survey wishes to acknowledge the many people and organizations that contributed information presented in this report. Numerous individuals at mineral and energy resource companies, state and federal government agencies, and trade organizations have provided us with the information necessary to create this annual summary of Colorado's mineral and mineral fuel activity. Listed below are some of the companies, agencies, and publications that contributed information for this report:

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