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Mineral and mineral-fuel production activities in New Mexico during 1988

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The total value of mineral and mineral-fuel production in New Mexico during 1988 increased 1.7% to \$4.7 billion despite continuing declines in the production and value of oil and gas (Table 1). Most of the increase was derived from the non-fuel sector, which rose to a record high of \$1.02 billion (Greeley and Eveleth, 1988).

The economic improvement in the copper industry is reflected by the record high production value of \$687 million, a 53% increase over that for 1987. Potash also rose a substantial 23% as a result of the benefits of the U.S.-Canadian Trade Agreement.

New Mexico continued to lead the nation in the production of potash and perlite and ranked second in the production of copper, mica, pumice, and sulfuric acid, derived from the smelting of base-metal sulfide ores (Greeley and Eveleth, 1988).

The year was marked by an increase in exploration activity, particularly for precious metals. Additionally, some interest was directed toward copper oxide deposits amenable to the solvent-extraction process, and for the first time in 20 years, at least one major company initiated a search for sulfur.

Mineral Fuels

Oil and Gas

In 1988, New Mexico was the seventh largest producer of crude oil and the fourth largest producer of natural gas in the United States. Production of crude oil and lease condensate in New Mexico during 1988 was approximately 71.2 million bbls, a decrease of 1.5% from the 72.3 million bbls produced in 1987 (Table 1). The Permian Basin of southeast New Mexico produced 90% of the state's oil while 10% came from the San Juan Basin of northwest New Mexico (Table 2). Oil production decreased by 0.37%, or 240 thousand bbls, in the southeast and by 11.1%, or 850,000 bbls, in the northwest. The estimated value of oil produced during 1988 was \$1,041 million, a decrease of 14.4% from the \$1,217 million value produced during 1987 (Table 1). The decrease in oil production resulted partly from a decrease in the productive capacity of many oil fields and partly from a decline in the price of oil.

Production of natural gas in New Mexico during 1988 was approximately 781 billion ft³ (BCF), a decrease of 4.0% from the 814 BCF produced during 1987 (Table 1); 53% of the state's gas was produced from southeast New Mexico and 47% from northwest New Mexico (Table 2). Gas production decreased by 2.13%, or 9.0 BCF, in the southeast by 6.03%, or 23.5 BCF, in the northwest. The estimated value of gas produced during 1988 was \$1,359 million, a decrease of 1.2% from the \$1,375

million value of gas produced during 1987 (Table 1). The depressed market for New Mexico gas in California resulted in decreased production and decreased total value of New Mexico gas during 1988.

Production of natural gas liquids in New Mexico during 1988 was approximately 50.1 million bbls, an increase of 2.5% from the 48.8 million bbls produced during 1987 (Table

1). The estimated value of natural gas liquids produced was approximately \$702 million, an increase of 1.4% from the estimated \$692 million produced during 1987.

Exploratory drilling in New Mexico decreased slightly during 1988; 134 exploratory wells were drilled during 1988, a 1% decrease from the 133 wells drilled during 1987

TABLE 1—Mineral and mineral-fuel production in New Mexico during 1988. Thousand short tons unless otherwise noted. NA, not available; XX, not applicable; E, estimated (subject to revision); R, revised. Data sources: Greeley and Eveleth, 1988; U.S. Department of Energy; New Mexico Oil Conservation Division, Oil and Gas Accounting Division; New Mexico Energy, Minerals, and Natural Resources Department, and Department of Taxation and Revenue. * 1 bbl = 42 U.S. gal.

Commodity	1987		1988	
	Quantity	Value (thousand dollars)	Quantity	Value (thousand dollars)
Carbon dioxide (million ft ³)	134,129	67,994	135,449	47,094
Clays	51	141	31	83
Coal (sales figures only)	20,697	479,722	21,594	498,317
Copper	271,755 ^R	448,373 ^R	385,123	687,182
Gem stones	NA	200	NA	200
Helium, grade A (thousand ft ³)	39,810	1,473 ^E	37,478	1,387 ^E
Natural gas (million ft ³)	813,717	1,375,181	781,166	1,359,228
Natural gas liquids (thousand bbls*)	48,818	692,204 ^E	50,052	701,829 ^E
Perlite	437	13,611	458	14,294
Petroleum, crude (thousand bbls*)	72,328	1,217,278	71,235	1,041,450
Potash	1,458	174,200	1,401	213,800
Pumice	87	991	84	852
Sand and gravel: construction	8,600 ^E	31,000 ^E	8,787	31,367
Stone, crushed	4,503	15,919	3,500 ^E	13,900 ^E
Stone, dimension	22	626	22	626
Uranium (thousand lbs)	2,334	68,059	2,250 ^E	50,000 ^E
Combined value of cement, gold, gypsum, iron ore, lead, mica (scrap), molybdenum, pyrites (1987), salt, and silver	XX	51,310	XX	54,841
Total		4,638,282		4,716,450

TABLE 2—Oil and natural gas production in New Mexico during 1988 and change from production during 1987. -, decline; +, gain. Data source: New Mexico Oil Conservation Division. 1 bbl = 42 U.S. gal.

County, area	Crude oil (bbls)		Natural gas (thousand ft ³)	
	1988 production	change from 1987	1988 production	change from 1987
Chaves	1,220,754	-108,825	31,149,121	-7,442,602
Eddy	10,613,359	+150,276	140,132,499	+7,208,601
Lea	51,582,438	-280,280	238,740,320	-9,615,129
Roosevelt	955,630	-914	4,628,283	+836,261
Southeast totals	64,372,181	-239,743	414,650,223	-9,012,869
McKinley	407,179	+1,004	61,489	+20,820
Rio Arriba	4,013,525	-727,451	148,599,639	-8,214,867
San Juan	2,212,938	-60,774	215,930,683	-15,002,724
Sandoval	228,756	-66,352	1,923,532	-341,569
Northwest totals	6,862,398	-853,573	366,515,343	-23,538,340
State totals	71,234,579	-1,093,316	781,165,566	-32,551,209

TABLE 3—Drilling statistics for oil and gas wells drilled in New Mexico during 1987 and 1988. * statewide success rate. Data source: New Mexico Oil Conservation Division.

	1987			1988		
	SE	NW	total	SE	NW	total
Exploratory wells	88	34	133	92	36	134
oil	35	4	39	27	4	31
gas	14	21	35	19	20	39
success rate (%)	56	74	54*	47	67	52*
Development wells	637	166	803	701	269	970
oil	396	75	471	456	70	526
gas	146	79	225	120	156	27
success rate (%)	85	93	87*	82	84	83*

(Table 3). Most of the loss in exploratory completions was caused by a continued slump in oil exploration in the northwestern part of the state; only 4 exploratory oil wells were drilled in the northwest in 1988. The success rate for exploratory wells decreased from 54% in 1987 to 52% in 1988. Success rates in both years were higher in the northwest than in the southeast.

There was a 21% increase in the total number of development wells drilled during 1988; 970 wells were drilled, up from the 803 drilled during 1987. The increase in development drilling resulted partly from increased development of coal-bed methane reserves in San Juan and Rio Arriba Counties. This drilling "boom" was caused by two factors. First, a federal gas-production tax credit is in effect for coal-bed methane wells drilled prior to 1991; the tax credit applies to gas produced from those wells until the year 2001. Operators have rushed to develop their reserves before the 1991 deadline. Second, the past two years have seen an improved understanding of the production technology of coal-bed methane.

Proved oil reserves in New Mexico increased 1.1% from 654 million bbls at the end of 1987 to 661 million bbls at the end of 1988 (Table 4). The addition to proved reserves from discoveries of new fields was approximately 1 million bbls. Extensions of old reservoirs and discovery of new reservoirs in old fields added an additional 20 million bbls. Production of crude oil, however, exceeded discoveries in 1988 by 50 million bbls. The increase in reserves reported for 1988 was caused by corrections, adjustments, and revisions of previously reported reserve calculations.

Proved natural gas reserves in New Mexico increased 46.4% from 12,621 BCF at the end of 1987 to 18,483 BCF at the end of 1988 (Table 4). The addition to proved reserves from discoveries of new fields was approximately 1 BCF. Extension of old reservoirs in existing fields and discovery of new reservoirs in old fields added 1,309 BCF. The increase in reserves in 1988 was caused primarily by addition of coal-bed methane in the San Juan Basin of northwest New Mexico, which had not been included in previous reserve estimates. Exploration for, and discovery of, conventional gas reserves continued to decline in 1988.

Proved natural gas liquids reserves in New Mexico increased 32.7% from 771 million bbls at the end of 1987 to 1,023 million bbls at the end of 1988 (Table 4). Reserve additions exceeded production. No reserves of natural gas liquids were added from discovery of new fields. Extensions of old reservoirs in existing fields and discovery of new reservoirs in old fields added 67 million bbls. Most of the increase of reserves came from corrections, adjustments, and revisions of previously reported reserve calculations.

Coal

New Mexico coal production for 1988 reached a record high of 21.7 million short tons (Table 5). Production in 1988 was 0.63% higher than the previous high for the state set in 1985 (21.6 million short tons) and 1.12% higher than coal production in 1987. The large-scale strip mines in the San Juan Basin produced 78% of the total 21.7 million short tons. In the Raton Basin the only underground mine in the state, operated by Kaiser Coal Corp., produced 1% of the year's total coal production. The remaining 21% came from smaller surface mines in the San Juan and Raton Basins. Total coal sold was 21.6 million tons, an increase of 4.33% over 1987 (Table 1). In 1987 more coal was sold than produced, accounting for the smaller increase in 1988 of amounts sold versus produced. The average price fell from \$23.18 per ton in 1987 to \$23.08 in 1988; the total value of the coal sold in 1988 was \$498,317,185 (Kay Hatton, New Mexico Energy, Minerals, and Natural Resources Department, personal communication 1989). The increase in production is attributed to droughts in the northwest U.S. and the need to use of coal-generated electricity to supplement hydro-electric power and also the acquisition of new contracts by some of the larger strip mines. Nine mines produced coal in New Mexico in 1988, four of which (McKinley, Lee Ranch, Navajo, and De-Na-Zin) showed significant increases from 1987.

Production decreased at the mines in the Raton Basin (York Canyon Surface, York Canyon #1, and Cimarron mines) because of Kaiser Coal Corp.'s continued difficulties in selling these properties. During 1988 Kaiser idled their properties several times because of a lack of operating capital. Kaiser

TABLE 4—Contributions to proved reserves from discoveries in 1987 and 1988. Data from Energy Information Administration (1988, 1989). Natural gas liquids reserves includes lease condensates. *1 bbl = 42 U.S. gal.

	1987	1988
Added oil reserves from discovery of new fields (million bbls*)	1	1
Added oil reserves from extension of existing fields and discovery of new reservoirs in existing fields (million bbls*)	13	20
Total proved oil reserves (million bbls*)	654	661
Added gas reserves from discovery of new fields (billion ft ³)	1	1
Added gas reserves from extension of existing fields and discovery of new reservoirs in existing fields (billion ft ³)	157	1,309
Total proved gas reserves (billion ft ³)	12,621	18,483
Added natural gas liquids reserves from discovery of new fields (million bbls*)	0	0
Added natural gas liquids reserves from extension of existing fields and discovery of new reservoirs in existing fields (million bbls*)	10	67
Total proved natural gas liquids reserves (million bbls*)	771	1,023

settled with Salt River Project on a buy-out agreement of their contract, which allowed them to proceed with negotiations to sell the mines. By the end of 1988 Kaiser had reached an agreement with Pittsburg and Midway Coal Co. to purchase the Raton coal properties, but the mines remained idle due to lack of funds and markets.

In December of 1988 Public Service Company of New Mexico announced plans to sell its non-utilities businesses, which include the De-Na-Zin and Gateway mines operated by its subsidiary, Sunbelt Mining. Both mines were closed in mid-December with no plans to reopen. The Mentmore and Carbon No. 2 mines operated by Carbon Coal Company near Gallup are in the reclamation stage. No new permits were issued in 1988.

Metallic commodities

Copper

Market analysis—Refined copper stocks held in warehouses such as by Comex have been dropping steadily since 1983 (Engineering and Mining Journal, 1989a, p. 18). Despite this fact, prices have remained stubbornly low, in the \$0.60–\$0.70/lb range, until late in the third quarter of 1987 when the market responded rapidly. Prices began in 1988 at a healthy \$1.45/lb and continued to rise until year end. U.S. producers cathode

TABLE 5—New Mexico individual coal-mine production. U, underground; NP, no production; *, tonnage produced after washing. Data source: Kay Hatton, New Mexico Energy, Minerals, and Natural Resources Department, personal communication 1989.

Mine	Owner	Production (short tons)	
		1987	1988
Cimarron (U)*	Kaiser Coal Corp.	604,807	221,810
York Canyon #1 (U)*	Kaiser Coal Corp.	NP	NP
York Canyon Surface*	Kaiser Coal Corp.	920,617	621,030
McKinley	Pittsburg and Midway Coal Co.	3,563,360	5,092,179
Navajo	Utah International	7,343,000	9,087,000
San Juan	San Juan Coal Co.	3,128,220	2,847,000
La Plata	San Juan Coal Co.	1,628,034	1,538,133
De-Na-Zin	Sunbelt Mining Co.	51,385	106,113
Gateway	Sunbelt Mining Co.	172,324	116,485
Lee Ranch	Santa Fe Pacific Coal Corp.	1,972,971	2,107,104
Fence Lake #1	Salt River Project	100,036	closed
	Total	19,484,754	21,736,854

achieved a record high of \$1.63/lb on December 26 (Metals Week, 1988f, p. 5). At one point, worldwide stocks were said to be down to a three-week supply, the lowest level since the American Bureau of Metal Statistics began to keep records in 1950 (Metals Week, 1988i, p. 8). Copper prices will likely remain elevated until production and demand fall back in line.

Phelps Dodge—Phelps Dodge Corp., the largest producer both in the nation and in New Mexico, experienced a banner year. A record amount of copper, 581,600 short tons (st), was produced by the firm, 15% of which was for its partners (Sumitomo at Morenci, Arizona, and Mitsubishi at Chino). Total production from the New Mexico properties was 236,600 st, exclusive of Mitsubishi's one-third share of Chino (Phelps Dodge, 1989a, p. 9; 1989b, p. 4).

Phelps Dodge continued to operate its new Chino property to increase production efficiency and decrease costs. The most significant improvement is the solvent-extraction plant (solvex), construction of which began in September 1987. Brown and Root was the prime contractor. The plant became operational in August 1988, about a month ahead of schedule, and was officially dedicated October 31. When in full production, the Chino solvex plant is designed to produce about 45,000 st/annum (approximately 120 st/day) of electrowon copper. Daily production during startup is estimated at 80 st. Daily ore production at Chino averages about 190,000 st, 45,000 st of which are shipped to the concentrator. Material earmarked for solvex, some 80–90,000 st, is mostly chalcocite ore grading about 0.3% Cu. Solvex ore is stacked about 30 feet in height on leach pads and undergoes a 120-day leach cycle. Ultimately eight or more 30-ft lifts may be stacked on the pads. Production costs are roughly similar to those at the Tyrone plant where costs are less than \$0.30/lb.

Other improvements at Chino were made on the smelter and tailing dam. Smelter maintenance was scheduled to begin in mid-

August and included general repairs to the flash furnace and a complete replacement of the heat exchanger. The "new" unit was salvaged from the Phelps Dodge smelter idled Morenci, rebuilt in Salt Lake City by Eaton Metal Products, and hauled (by truck!) to Hurley. Contractor for the project was Chemetics of Ontario, Canada (Pay Dirt, 1988b, p. 10A). The smelter was back in operation by September 5.

During smelter shutdown, both mine and mill continued to operate and concentrates were stockpiled. Concentrate shipments from Tyrone were curtailed until the Hurley plant could draw down the Chino stockpile.

The new tailings-impoundment area southeast of Hurley has been designed to contain all tailings produced during the projected life of the Chino operation. The tailings will eventually cover some 1,600 acres and reach a height of 255 ft (Silver City Daily Press, p. 1).

Reserves at Chino are estimated at 224,700,000 st grading 0.71% Cu. Average grade of Chino's reserves dropped substantially in 1988 probably due to the necessity of increasing ore/waste stripping ratio. At current mining rates (11,145,000 st in 1988) Chino's reserves should last a little over 20 years (Phelps Dodge, 1989a, pp. 9–10).

At Tyrone, a third expansion of the solvex plant was underway. This latest expansion is expected to double the capacity to 55,000 st/annum beginning January 1989. Tyrone's conventional smelting reserves of 79,800,000 st will be depleted in the early 1990's. Solvex production is expected to continue for an additional 15 years (Phelps Dodge, 1989a, pp. 4, 10; 1989b, p. 4).

Annual maintenance at the Hidalgo smelter was originally scheduled for late March, but repairs to the waste-heat boiler forced an earlier shutdown beginning February 25. Carefully planned maintenance at Phelps Dodge's flagship smelter has rewarded the company with record production runs such as the 293,700 st produced during 1986 and has ensured that delivery commitments are ade-

quately covered (Metals Week, 1988a, p. 1).

Cyprus Minerals—Cyprus Minerals Inc., a relative newcomer to New Mexico, became the nation's number two copper producer after the recent purchase of Inspiration Consolidated Copper Co. Cyprus, in late July 1987, assumed operations of the Pinos Altos property previously held by Boliden Minerals. Cyprus subsequently entered a joint-venture agreement with Goldfield Corp. in which the latter would provide use of its milling facilities at Chloride. The joint venture has been beneficial to both companies as well as to several contractors who provide such services as mining and trucking.

The Pinos Altos mine produces two salable products: ore-grade material shipped to Goldfield's St. Cloud mill for concentration and a lower grade, high-silica product shipped directly to regional smelters for use as flux (St. Cloud, personal communication 1989). Joint-venture production reached full capacity during February. St. Cloud processed 122,630 st of Pinos Altos ore grading 4.73% Cu. In addition, 44,262 st of siliceous flux grading approximately 2.4% Cu was shipped. Total recovered copper amounted to 5,172 st (Goldfield, 1989b, p. 6).

Cyprus is apparently not interested in extending the joint-venture agreement with Goldfield beyond the original term ending in early 1990. Cyprus, seeking milling facilities of its own, examined the possibility of purchasing or leasing Asarco's concentrator at Deming. Should this arrangement be completed, Cyprus would also gain the advantage of a shorter haul because the Deming concentrator is just 55 miles from the mine. Cyprus began the year with known reserves of about 1 million st grading 4.9% Cu (Engineering and Mining Journal, 1988a, p. 69).

Goldfield/St. Cloud—Primarily as a result of the joint-venture activities with Cyprus, Goldfield experienced a turnaround in profits beginning the first quarter of 1988 and reported operating profits for the year of \$3.3 million. The joint venture will terminate during the first quarter of 1990 (Goldfield, 1989c, p. 1), so the company is aggressively developing minable reserves at its Midnight property near Chloride to provide future millfeed. Some 4,266 st of ore have been stockpiled at the mill for future processing. St. Cloud also produced 13,934 st of ore mined specifically for smelter converter flux containing 29,582 lb Cu as well as some precious metal (see Gold/Silver).

In addition to Goldfield's core properties (St. Cloud and U.S. Treasury), the company holds interests in the above-mentioned Midnight and Ivanhoe-Emporia mines in the Chloride area and the Great Republic, Fluorine, Elephant, and Minnehaha mines in the northern portion of the Black Range (Goldfield, 1989b, p. 4).

Leaching Technologies, Inc.—Testing and research at the Nacimiento copper deposit near Cuba in Sandoval County continued during the year. Leaching Technologies Inc. has been experimenting with in situ leaching

methods similar to those developed in the uranium leaching industry in which a production well is surrounded by four injection wells. Leachate, primarily sulfuric acid solution, is pumped into the copper-bearing sandstone formation dissolving the copper minerals. Copper-laden solution is then recovered through the production well and circulated through electrowinning cells, in which the copper metal is precipitated. The company hopes to be in production in 1989 producing 7,000–8,000 lb/day at a cost of less than \$0.40/lb.

Sharon Steel Corporation—Sharon Steel's Continental mine property at Fierro remained officially closed for yet another year. However, negotiations were underway with at least two active mining companies interested in a possible joint venture that would put the long-dormant property back in operation. When the property ceased operations in January 1982, sustained copper prices in the mid-\$.80/lb range were said to be necessary for continued operations. Copper prices over the last year have obviously been high enough to generate joint-venture interest. Reserves at the Fierro property include 10.3 million st of underground ore grading 1.97% Cu; 11.7 million tons of surface-minable ore grading 0.86% Cu; and an additional 9.9 million tons grading 0.63% Cu on Hanover Mountain that may be amenable to solvent extraction (Sharon Steel Corp., 1981, p. 11; 1984, p. 59). The Continental property consists of several thousand acres of mineralized ground with interesting potential. Drilling carried on by Sharon Steel until shutdown indicated several previously unmined areas that deserve further evaluation.

Exploration activity—With an average price of nearly \$1.15/lb for the year, geologists have once again become interested in exploration targets, particularly those amenable to solvent extraction. New Mexico has few known deposits, but those that have been re-examined include the Sixty Copper prospect west of Magdalena and a few of the red-bed deposits in east-central New Mexico.

Gold/Silver

Market analysis—The bulk of New Mexico's precious-metal production was again derived as a by-product of the electrolytic refining of copper bullion. Phelps Dodge Corp., with ongoing mining operations at both Tyrone and Chino in Grant County, was by far the largest producer, Tyrone of silver and Chino of gold. Lesser but still significant production was reported by three other firms. Additional precious-metal production may be forthcoming when properties currently in the exploration stage are brought into production.

Cyprus Minerals/St. Cloud joint venture—The Cyprus/St. Cloud joint venture was the third-ranked precious-metal producer during 1988. As discussed under Copper, Cyprus produces two products at Pinos Altos, one shipped to Chloride for concentrating in St. Cloud's mill and the other, a high-

silica product, shipped directly to regional smelters for flux. St. Cloud produces three products: ore mined specifically for flux, additional ore stockpiled at the mill for future concentration, and reclaimed mill tailings suitable for flash-furnace flux. All these products contain varying amounts of gold and silver.

Precious metals recovered from Pinos Altos concentrates and ores sold for flux amounted to 408,491 oz Ag and 1,420 oz Au (Goldfield, 1989b, p. 6). St. Cloud produced 13,934 st of siliceous converter flux that yielded 107,066 oz Ag and 268.8 oz Au. Additionally, 39,619 tons of mill tailings were sold for flash-furnace flux containing about 0.01 oz Au/t and 1.0 oz Ag/t (Goldfield, 1989a, p. 4; 1989b, pp. 4, 5; St. Cloud, personal communication 1989).

Ongoing exploration and development at the St. Cloud properties have identified approximately 450,000 st of reserves grading 0.6% Cu/t, 5.76 oz Ag/t, and 0.034 oz Au/t. A significant portion, however, may not be economically recoverable at today's metal prices (Goldfield, 1989b, 10–K, p. 4).

Westar Corporation—Westar Corp. brought its cyanide heap-leaching facility into full production on schedule by January 1988. Westar's large property has been undergoing exploration and development for the last five years, originally under a joint-venture partnership with Phelps Dodge Corp. and Federal Resources. Phelps Dodge dropped out soon after initial drilling was completed, and last year Westar announced it would purchase the Lordsburg assets of Federal Resources.

The first doré (unrefined) bullion was actually poured late in 1987; by January 1988 the firm was in full production and shipped its first bullion. Westar has announced proven bulk-minable reserves of about 500,000 st and the Lordsburg properties are thought to hold potential for additional discoveries. The company has invested a little over \$2 million in the project thus far and is also involved in other joint-venture projects in Nevada and Montana (Mining Record, 1988a, p. 1).

Canyon Resources—Canyon Resources announced a joint-venture agreement with Phelps Dodge Corp. to explore the former's precious-metal property near Signal Peak in the Tierra Blanca district southwest of Hillsboro, New Mexico. With the expenditure of \$400,000 over a four-year period plus a \$55,000 payment to Canyon, Phelps Dodge may earn 51% interest in the so-called Pierce Canyon property. Exploration activity is focusing on an area approximately 6,500 ft long and 200 ft wide containing anomalous gold values in quartz veins. Exploration was active throughout much of the year although no values have been announced. A former joint-venture partner, Texaco, had completed about 7,000 ft of drilling in 23 holes. Texaco subsequently pulled out of mining activity altogether and abandoned the joint venture (Canyon Resources, 1985, p. 26; Mining Record, 1988b, p. 73; 1988c, p. 43).

Pioneer Metals Corporation—Pioneer

Metals Corp. of Vancouver, B.C. conducted ongoing exploration and evaluation at its gold-silver property, the old Great Western mine, near Ruidoso in Lincoln County. Pioneer had previously announced a discovery of 3.6 million st grading 0.053 oz Au equivalent (i.e., gold plus silver values stated as gold). Other breccia-type deposits were also examined during the year. The ore zone at the Great Western appears to be "open" in all directions (i.e., no "end" to the deposit has yet been encountered) (Engineering and Mining Journal, 1988c, p. 121, 123). Pioneer is now seeking operating permits and an Environmental Impact Statement will doubtless be required by the U.S. Forest Service.

La Paz Mining Co.—La Paz Mining Co. of Tucson, Arizona, attempted to restart its small gold placer property on Bear Creek near Pinos Altos but was ordered to cease operation by the U.S. Army Corps of Engineers. Subsequent to enactment of the Clean Water Act of 1977, all placer operations have been subject to a permitting procedure under Section 404 of the Act, a procedure administered by the Corps of Engineers. La Paz was denied this permit and was forced to abandon the project after reclaiming the area, sustaining a loss of about \$1 million.

NovaGold Resources—Much new attention has been directed toward the Steeple Rock district over the past few years. Recently NovaGold Resources of Nova Scotia, Canada, obtained substantial positions at two Steeple Rock properties: the Summit group about 1 1/2 miles north of the old Carlisle mine; and the East Camp group about 2 miles east-southeast of the Carlisle mine.

The Summit group consists of a core of 10 patented and 14 unpatented claims around which NovaGold has staked an additional 71 claims. Previous evaluation work completed by Inspiration Mines Inc. indicated the presence of more than 1 million tons of ore grading 0.06 oz Au/t and 4 1/2 oz Ag/t. The Steeple Rock ores are highly siliceous and have been in demand for flux at regional smelters. NovaGold continued exploration throughout the year and announced the discovery of some "bonanza" ore on the Summit property. Several operational possibilities were being considered by the company, including cyanide heap-leach extraction. NovaGold is now seeking a joint-venture partner to participate in further evaluation and development work (NovaGold Resources Inc., 1988, pp. 23–26).

At the East Camp group, NovaGold obtained an option on the MacDonald, Nugget, Davenport, and Gold Bug claims and has located an additional 55 claims surrounding the core properties. An exploration and drilling program is planned (NovaGold, 1988, pp. 26–27).

Exploration activity—At least three exploration projects were in the drilling phase during 1988. LAC Minerals continued to evaluate its gold property on the Ortiz Mine Grant near Santa Fe. LAC owns the old Conoco holding amounting to about 20,000 acres on the southern portion of the grant. The

company announced late in the year that the exploration project had matured to the point where a decision regarding possible development could be made. Previously, LAC had identified two mineralized zones: the Carache Canyon deposit containing 5 million st grading 0.1 oz Au/t and the Lukas Canyon deposit containing 6 million st grading 0.04 oz Au/t.

Molybdenum

Market analysis—Molybdenum prices improved slightly during the year primarily because of a modest recovery in the steel industry. Demand actually outstripped supply for the second consecutive year and helped draw down some of the large inventories. Molybdenum oxide prices began the year in the \$3.00/lb range and improved steadily throughout mid-March when the price surged to about \$4.00/lb. Several factors, including production problems at Chile's Chuquicamata facility as well as unusually heavy purchases by the Japanese, contributed to the price increase (Metals Week, 1988b, p. 6). Unfortunately, prices had slipped back to pre-March levels by midyear, closing the year in the \$3.50/lb range, still up a healthy 14% since January (Metals Week, 1988h).

Phelps Dodge—Molybdenum was produced at just one property in New Mexico during 1988—Phelps Dodge's Chino mine. As noted in an earlier report (Eveleth, 1988, p. 17), Phelps Dodge tendered its "1988" molybdenum production in late December 1987. The company announced in October that it would not tender its "1989" production but instead would dispose of the estimated 1.4 million lbs of production through a private arrangement (Metals Week, 1988d, p. 3).

Molycorp—Despite persistent rumors of pending reopening of the Questa mine, the facility remained closed during 1988. Unocal, the parent company of Molycorp, was engaged in considerable behind-the-scenes activity, however. Operating costs have been reduced by renegotiating power and labor contracts. Early in the year, in an effort to decrease overhead costs, Unocal took a \$105 million before-tax write-down of Molycorp, including the Questa mine and mill (Metals Week, 1988c, p. 7).

Toward the end of the year, Unocal approached several major buyers and consumers in an attempt to negotiate long-term sales contracts but met with no success. Unocal even considered the outright sale of the entire Molycorp operation (including the Washington, Pennsylvania, roasting plant), but the \$100 million price tag attracted no buyers (Metals Week, 1988e, p. 6).

Molycorp continued to negotiate with the Bureau of Land Management for approval of its proposed Guadalupe Mountain tailing site but has met with increasing resistance and hostility from environmental groups. The new dam would likely have significant visual, if not other, impacts on the area. The facility would require the withdrawal of more than

TABLE 6—Discovered resources of uranium, by state as of December 31, 1988, divided into two categories: economic reserves and reasonably assured resources (Energy Information Administration, 1989). The U.S. Department of Energy has adopted the International Atomic Energy Agency terminology. It is the author's opinion that these figures for New Mexico are too low; possibly the Mt. Taylor reserves are not included.

	Economic reserves		Reasonably assured resources (RAR)			
	Quantity (thousand tons)	Grade (% U ₃ O ₈)	Forward-cost categories			
			Quantity (million lbs U ₃ O ₈)	\$30/lb (million lbs U ₃ O ₈)	\$50/lb (million lbs U ₃ O ₈)	\$110/lb (million lbs U ₃ O ₈)
New Mexico	42,806	0.104	89.0	177	447	673
Wyoming	64,159	0.138	173.9	68	348	606
Texas	17,950	0.088	31.5	8	28	55
Other states	3,877	0.270	74.8	36	158	226
United States total	137,792	0.134	369.2	289	981	1560
New Mexico/U.S. total (%)	—	—	24	61	46	43

1,200 acres of land and the dam would reach an ultimate height of 300 ft.

Uranium

The uranium industry in New Mexico in 1988 as in the rest of the nation was plagued with low prices, increased foreign imports, and political uncertainties (Chenoweth, 1989). Although exploration, development drilling, and employment in the industry increased in 1988, production in the state slightly decreased.

Just two mines operated during the year: Chevron's Mt. Taylor and Homestake's Section 23 mines. Both shipped their ore to the Homestake mill for processing. Additionally, both the Homestake mill and the Kerr McGee (now Rio Algom, Ltd.) mill recovered uranium from recirculated mine water. A few companies examined various New Mexico properties as sites for solution mining, and Uranium Resources, Inc. (URI) announced plans to use this process at the Church Rock mine.

In 1988, for the fifth consecutive year, the domestic uranium industry was declared nonviable by the Department of Energy (DOE). The spot market price began in January 1988 at \$16.55/lb of U₃O₈ and declined throughout the year to \$11.75/lb of U₃O₈, although the average contract price was estimated at \$35.49/lb of U₃O₈ (Chenoweth, 1989). Canadian uranium sales to domestic consumers are expected to increase due to the United States-Canada Free Trade Agreement, which created a free uranium market between the two countries. In addition, the United States Supreme Court reversed a lower-court decision that would have prohibited the DOE from enriching foreign uranium for use in domestic reactors (Chenoweth, 1989).

Spring of 1988 was somewhat encouraging for New Mexico's uranium industry, however. Chevron began shipping Mt. Taylor ore to the Homestake mill for processing; previously Mt. Taylor ore was shipped to south

Texas to a Chevron mill. The Mt. Taylor deposit contains total reserves of 120 million lbs of U₃O₈ at an average grade of 0.35% U₃O₈ in sandstones of the Westwater Canyon Member of the Morrison Formation (Jurassic). The ore is mined through two shafts, 3,300 ft deep (Alief and Kern, 1989). In February, the Public Service Company of New Mexico (PNM) announced the awarding of a contract to Uranium Resources Inc. (URI) to supply uranium to the Palo Verde Nuclear Generating Station. URI plans to use solution mining in the Morrison sandstone at the Church Rock mine near Gallup (New Mexico Mining Association, 1988). In March, Homestake began the complex process of obtaining permits to mine La Jara Mesa deposit at Grants. La Jara Mesa deposit contains at least 2.5 million lbs of U₃O₈ at an average grade of 0.33% U₃O₈ in the Poison Canyon sandstone of the Morrison Formation, and would be mined through two adits.

In terms of uranium production, New Mexico ranked behind Utah, Texas, and probably Wyoming. The Department of Energy was unable to release individual production statistics for some of these states, including New Mexico, to avoid disclosure of proprietary data. The New Mexico Energy, Minerals, and Natural Resources Department estimated 1988 uranium production at 2.2 million lbs of U₃O₈ in concentrates for a total estimated value of \$50 million (Albuquerque Journal, June 25, 1989), or about 17% of total United States uranium production (Energy Information Administration, 1989b; McLemore and Chenoweth, 1989). In 1987, uranium production from New Mexico amounted to 2.33 million lbs of U₃O₈, including ore processed in Texas (McLemore and Chenoweth, 1989).

While several companies continued assessment work in New Mexico, Mobil de-commissioned its Crownpoint properties. Reclamation continued at the old Phillips (United Nuclear) mill near Grants where 2.6 million tons of low-grade mill tailings were

buried and 700 acres at the mill site were cleaned of radioactive waste.

Although New Mexico possesses a large portion of the country's economic reserves and reasonably assured resources (Table 6), the future of the state's uranium industry is uncertain. Most of the reserves and resources in New Mexico are deep, deeper than 1,000 ft, and are lower in grade compared to the unconformity-type uranium deposits in Canada and Australia. Continued development of uranium resources in New Mexico will depend on 1) higher uranium prices, 2) lower production costs, perhaps by use of solution mining, 3) discovering higher grade deposits or raising the mining-grade cutoff, and 4) assisting potential mining companies with the complexities of processing permits, licenses, and environmental regulations, all of which are required now to mine uranium in the state.

Industrial minerals

Potash

Carlsbad is still the nation's premier potash-producing area, contributing about 85% of all potash mined in the United States. However, that number is somewhat misleading in that it represents just 5% of the total potash sold in the country; Canadian exports account for 85% of the potash used in the U.S. Canada was allegedly dumping its potash in an effort to gain control of the entire market.

The result, until this year, was that Carlsbad as a potash producer was dying; the district simply could not compete against insurmountable Canadian competition. When Canada finally agreed on January 8 of this year to cease its dumping practices, the market began to improve immediately. Posted prices began the year in the \$51/ton range and rose to the \$92-\$102/ton range by year end (Industrial Minerals, 1988b, p. 83). The district began to reap the benefits immediately: one property slated for closure during 1989 will now remain in operation as long as market conditions warrant and another mine, closed since 1983, reopened.

Lundberg Industries—Following grand jury indictments against nine former Lundberg company officials including the president, a Dallas, Texas, bankruptcy court appointed a trustee to oversee the mine operation. Meanwhile, the bankruptcy court accepted proposals from four companies qualified to take over the operation. The four were Trans-Resources, Inc.; Nu-West Industries, Inc.; Frontier International Group, Inc.; and the previous owner, Ideal Basic Industries.

On June 7 the court selected the plan submitted by Trans-Resources as the most beneficial of the four. It includes paying more than \$25 million in debts over the next few years as well as establishing an insurance benefit fund for retirees. The mine became Trans-Resources' second Carlsbad property; it also operates the facility previously owned

by Kerr McGee. The new division operates under the name of Eddy Potash Co. and officially began operations June 28 (Pay Dirt, 1988a, p. 6A).

Amax—This company was looking ahead to a projected shutdown in 1989; however, market improvements brought about by the U.S.-Canadian trade agreements allowed Amax to develop ore in an upper zone despite the fact that the zone is narrower and more difficult to mine and the ore is of lower grade. Amax produced 570,000 st of potash in 1988, but the Carlsbad property received not even honorable mention in the firm's annual report (Amax Inc., 1989, p. 18).

Amax is also now the operator of the potassium sulfate plant at Dumas, Texas, under a lease agreement from Ideal Basic Industries. This plant was involved in the Lundberg imbroglio, but Ideal Basic was permitted by the bankruptcy court to repossess this segment of their former operations.

Mississippi Chemical Corporation—Mississippi Chemical Corp. (MCC) reopened both its New Mexico properties during the year but has pared down its operations elsewhere. The New Mexico operations include the compaction plant previously owned by National Potash Corp. MCC's mine reopened October 1, and the compaction plant was scheduled to reopen in early December.

MCC sold its fertilizer plant in Pascagoula, Mississippi, but still retains a nitrogen fertilizer plant at Yazoo City, Mississippi, and part ownership of another plant at Donaldson, Louisiana (the latter a joint-venture partnership with First Mississippi Corp.). MCC owns the largest known potash reserves in the United States, and market conditions permitting, the New Mexico properties may enjoy a potential lifespan of a century or more (Mississippi Chemical Corp., 1988a, p. 9; 1988b, pp. 12, 15).

International Minerals & Chemical Corporation—IMC Fertilizer Group, Inc., previously International Minerals & Chemical Corp., operated throughout the year posting near-record production of 955,000 st of potash. The company enjoyed particularly strong demand for its exclusive potassium sulfate fertilizer product, 'Sul-po-mag'. Acquisition of additional milling facilities brought in from another division in Florida permitted a 40% increase in the production of this product (IMC, 1988, p. 5).

Gypsum

American Gypsum Co., a wholly owned subsidiary of Centex Corp., one of the nation's largest home builders and contractors with interests in cement and gypsum wallboard, operated its Albuquerque wallboard plant at capacity during the year. Early in 1988, Centex announced that it would construct a new wallboard plant in Bernalillo, north of Albuquerque. The new plant is scheduled to begin operation in FY 1989-1990 and this will more than double Centex's current capacity. The plant will produce standard 1/2" wallboard as well as other specialty

wallboard products (Industrial Minerals, 1988a, p. 75; Centex Corp., 1988, pp. 13, 15).

Sulfur

The sulfur sector of New Mexico's industrial mineral industry has evoked little interest since Pennzoil brought its Culberson mine into production in 1969. Geologists searched unsuccessfully in neighboring New Mexico counties for similar deposits amenable to the Frasch extraction process. The state has produced some \$47.8 million worth of elemental sulfur since 1968, the first year the U.S. Bureau of Mines posted state statistics, but it was derived solely from petroleum refining (U.S. Bureau of Mines, 1968-1987). That may change if Gold Fields Mining Company exploration program is successful. Gold Fields obtained 38 sulfur exploration leases from the New Mexico State Land Office and began drilling near Hagerman during 1988. With elemental sulfur prices improving and known reserves dropping, Gold Fields hopes to enter the sulfur market in a big way (Industrial Minerals, 1988c, p. 21).

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angular boulders. These boulders do not move far unless they are on a steep slope. There they will move slowly downhill forming a long talus slope of broken rubble (Robinson et al., 1964).

There are a few mineral prospects located in Cimarron Canyon State Park and Colin Neblett Wildlife Area, but the history of them is unknown. They were probably developed in the late 1800's as part of the mining boom at Elizabethtown. The largest, the Horseshoe mine along US-64 (x, Fig. 1), consists of a short adit or tunnel dug into the hillside along quartz veins in Proterozoic metamorphic rocks. Pyrite, probably containing traces of gold, and malachite are found in dump samples. Other small prospects are scattered throughout the area (Leyenberger, 1983; Goodnight, 1973), but none of them ever produced economic quantities of ore. The area is protected from mineral exploration and development and has not been evaluated for its mineral resources.

Summary

Cimarron Canyon State Park and Colin Neblett Wildlife Area are popular attractions in north-central New Mexico because of the diverse recreational activities, spectacular scenery, and abundance of wildlife. Cimarron Canyon, formed by complex geologic processes, has served as a major travel route since prehistoric times, and today it is a major thoroughfare connecting Taos and Red River to the west with Raton and Springer on the high plains to the east. One of the more spectacular geologic attractions, the Palisades, is found in Cimarron Canyon State Park where many thousands of people ad-

mire the towering cliffs and rock formations each year.

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