Developments in uranium during 1990

William L. Chenoweth

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Abstract

Low prices, inventory liquidations, and foreign competition continued to plague the domestic uranium industry. As a result, the Secretary of Energy declared the domestic industry to be non-viable for the sixth straight year. Uranium-exploration expenditures in the United States continued at a very low level. In 1990, an estimated $6 million was spent on uranium, including 1.5 million ft of surface drilling. This drilling was done mainly in production areas and in areas of recent discoveries.

Production of uranium concentrate decreased markedly in 1990, when 10.2 million lbs of uranium oxide ($U_3O_{8)}$ were produced, a 26% decrease from 1989. Uranium produced from solution mining and as the result of the by-product of phosphoric-acid production accounted for about 42% of the total production in the United States. At the end of 1990, two uranium mills were operating in the United States.

In New Mexico, the closure of Chevron Resources' Mount Taylor underground mine, the Homestake Mining Co. mill, and Homestake's plant that recovered uranium from mine water, left the state with only 3% of the total United States uranium production.

For the seventh consecutive year, Canada was the world's largest producer and exporter of uranium. The large, high-grade reserves (+ 2% U_30_8) being developed in Saskatchewan will enable Canada to dominate the world market for many years. Uranium entering the market place from eastern Europe, including the Soviet Union, and from China will continue to keep prices low. Domestic uranium production is expected to decline in 1991 as additional mine and solution mining operations are closed.

Introduction

During 1990 the United States uranium industry declined markedly. Low prices, inventory liquidations, and foreign competition continue to plague the domestic industry. In December the Secretary of Energy, James Watkins, declared the domestic industry to be non-viable in 1989, for the sixth consecutive year. A similar declaration for 1990 is expected in late 1991.

A large amount of uranium entered the market place as some inventories were liquidated. The Soviet Union is emerging as a major supplier of uranium on the world market. Sales from their national inventory increased during 1980s. These sales contributed to keeping prices low. As measured by Nuexco's exchange value, the spot market price of uranium began 1990 at $9.00/1b U_30_8 and declined to $8.70/1b in March, then rose to $11.70/lb in August. After reaching this peak, the price declined slowly to $9.70/lb at the end of the year. A survey by the Energy Information Administration (EIA) of the DOE indicated that the average price of domestic uranium delivered to domestic utilities in 1989 was $19.56/lb U_30_8 and the average price of imported uranium was $16.75/1b (Energy Information Administration, 1990). Prices in 1990 were expected to be slightly lower than the 1989 level.

Throughout the free world, uranium consumption exceeded production in 1990 (Pool, 1991). This was especially true in the United States where consumption was 42.3 million lbs U_30_8 (Pool, 1991) and production, less exports, was 8.1 million lbs. As a result, the balance was made up from imports and inventories. During 1990 over 20% of the electricity generated in the United States came from nuclear plants. Environmental concerns over acid rain from coal-fired power plants may create an increased interest in nuclear power.

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Exploration

Twenty-seven companies reported that they spent a total of $14.8 million on domestic exploration during 1989 (Energy Information Administration, 1990). Foreign interests spent approximately 42 % of these dollars (Energy Information Administration, 1990). Included in these expenditures was 2.2 million ft of drilling. Exploration drilling in search of new deposits or extensions of known deposits accounts for 64 % of the total. Development drilling, which defines the size, shape, and grade of deposits and provides information needed for mine planning accounted for the remaining 36 %. Not included in the above statistics was 373,000 ft of drilling done for solution mining operations (Energy Information Administration, 1990).

A survey by the Energy Information Administration (1990) reported that companies planned to spend $6 million on domestic uranium exploration in 1990. After reaching a record $315.91 million spent on domestic exploration in 1979, expenditures have been on the decline. Since 1985, between $19-22 million have been spent annually on domestic exploration (Table 1).

TABLE 1-Exploration expenditures for uranium in the United States, 1971-1990. Source: 1971-1989, Energy Information Administration (1990), 1991 estimated.

Year	Millions of dollars
1971	41.00
1972	32.40
1973	49.47
1974	79.08
1975	122.03
1976	170.65
1977	258.08
1978	314.26
1979	315.91
1980	266.96
1981	144.76
1982	73.61
1983	36.86
1984	26.48
1985	20.10
1986	22.06
1987	19.67
1988	20.10
1989	14.77
1990	6.00

Surface drilling for uranium in 1990 is estimated to have been about 1.5 million ft, a decrease of 32% from 1989. Most of the drilling was done in Texas, Wyoming, Arizona, Utah, Nebraska, and Colorado. Less than 10,000 ft of drilling in New Mexico was reported to the Rocky Mountain Scout during 1990 (Robert D. Odell, pers. comm. 1991). This drilling was mainly for claim-assessment purposes throughout the *Grants* region. After reaching an all time high of 48 million ft in 1978, drilling has been declining (Table 2). Since 1983, drilling has been between 1.8 and 3.2 million ft per year (Table 2). The current level of 1.5 million ft is the lowest level of drilling since 1951 when 1.4 million ft were drilled (U.S. Department of Energy, 1983).

TABLE 2-Surface drilling for uranium in the United States, 1971-1990. Source: 1971-1989, Energy Information Administration (1990), 1990 estimated.

Year	Million ft Exploration	Development	Total
1971	11.40	4.10	15.50
1972	11.80	3.60	15.40
1973	11.76	5.25	17.01
1974	14.72	6.84	21.56
1975	15.69	9.73	25.42
1976	20.36	14.44	34.80
1977	27.96	17.62	45.58
1978	28.95	19.15	48.10
1979	28.07	13.01	41.08
1980	19.60	8.59	28.19
1981	10.87	3.35	14.22
1982	4.23	1.13	5.35
1983	2.09	1.08	3.17
1984	2.26	0.29	2.55
1985	1.43	0.34	1.76
1986	1.10	0.97	2.07
1987	1.11	0.96	1.96
1988	1.28	1.73	3.01
1989	1.43	0.80	2.22
1990	1.00	0.50	1.50

Production

Only one conventional mill operated continuously throughout the year, although three other mills operated part of the time, and two of these closed during the year (Table 3). By comparison, on January 1, 1981, 22 conventional mills were operating (U.S. Department of Energy, 1983).

TABLE 3-Conventional uranium mills in the United States operating in 1990.

Company	Location	Remarks
Chevron Resources Co.	Hobson, Texas	Operated all year
Homestake Mining Co.	Ambrosia Lake, New Mexico	Closed in February 1990
Pathfinder Mines Corp.	Shirley Basin, Wyoming	Closed in January 1990 reopened in Sept. 1990
Rio Algom Mining Corp.	Ambrosia Lake, New Mexico	Processed mine water only
Umetco Minerals Corp./ Energy Fuels Nuclear Inc.	Blanding, Utah	Placed on standby in October 1990

Uranium concentrate production in 1990 is estimated to have been about 10.2 million lbs U_3O_8, a 26 % decrease from the 13.8 million lbs U_3O_8 produced in 1989 (Energy Information Administration, 1990). Conventional mining, including the recovery of uranium from mine water, accounted for about 5.9 million lbs U_3O_8, or 58% of the total. The average grade of the ore milled in the United States during 1990 is estimated to have averaged 0.38% U_3O_8 (Table 4). While the production from the open pit mines in Wyoming and Texas and the underground mines in Colorado and Utah averaged between 0.20 and 0.28 % U_3O_8, the breccia pipe production in Arizona and a small amount of production in New Mexico raised the overall average to 0.38 % U_3O_8. Solution mining totaled 1.5 million lbs or 15 %. By-product uranium production from the manufacture of phosphoric acid amounted to 2.8 million or 27 % of the total production (Table 5).

The decrease in 1990 can be attributed to the permanent closure of Chevron Resources large underground Mount Taylor mine in New Mexico, the temporary shut down of Pathfinder Mines Shirley Basin open pit mine in Wyoming, and the closure of several solution mining operations in Wyoming and Texas.

The Energy Information Administration (1990) reported that domestic suppliers exported 2.1 million lbs U_3O_8 in 1989, down from 3.3 million lbs in 1980. Exports in 1990 were expected to be about 3.0 million lbs. Imported uranium, mainly from Canada and the Soviet Union totaled 13.1 million lbs U_3O_8 in 1989, down from 15.8 million lbs in 1988 (Energy Information Administration, 1990). Imports in 1990 probably exceeded 16 millions lbs U_3O_8.

TABLE 4-Grade of ore mined and/or milled in the United States, 1971-1990. Includes Mount Taylor ore milled in Texas. Source: United States 1971-1989, Energy Information Administration (1990), estimated. New Mexico 1971-1987,McLemore and Chenoweth (1989), 1988-1990estimated.

Year	% U_3O_8 United States	New Mexico
1971	0.21	0.23
1972	0.21	0.25
1973	0.20	0.23
1974	0.18	0.18
1975	0.16	0.16
1976	0.15	0.19
1977	0.15	0.18
1978	0.13	0.15
1979	0.11	0.12
1980	0.12	0.12
1981	0.11	0.12
1982	0.12	0.18
1983	0.13	0.24
1984	0.11	0.19
1985	0.16	0.28
1986	0.34	0.54'
1987	0.28	0.49'
1988	0.29	0.55
1989	0.32	0.55
1990	0.38	0.55

Domestic uranium-concentrate production reached a record 43.7 million lbs U_30_8 in 1980 and has declined since (Table 5). Since 1985, the annual uranium-concentrate production has been between 11.3 and 13.5 million lbs U_30_8 (Table 5).

TABLE 5-Uranium concentrate production in the United States, 1971-1990. Source: 1971-1989, Energy Information Administration (1990), 1990 estimated.

Year	Million lbs U_3O_8 Conventional mills	Solution mining and by-product operations	Total
1972	25.800	0.000	25.800
1973	26.459	0.011	26.470
1974	23.018	0.038	23.056
1975	23.183	0.017	23.200
1976	25.253	0.241	25.494
1977	29.878	1.159	29.878
1978	34.343	2.629	36.972
1979	33.753	3.719	37.472
1980	37.804	5.900	43.704
1981	31.997	6.477	38.474
1982	20.893	5.975	26.868
1983	15.515	5.639	21.154
1984	9.626	5.256	14.882
1985	6.084	5.230	11.314
1986	8.853	4.653	13.506
1987	8.536	4.455	12.991
1988	7.034	6.096	13.130
1989	8.175	5.662	13.837
1990	5.900	4.300	10.200

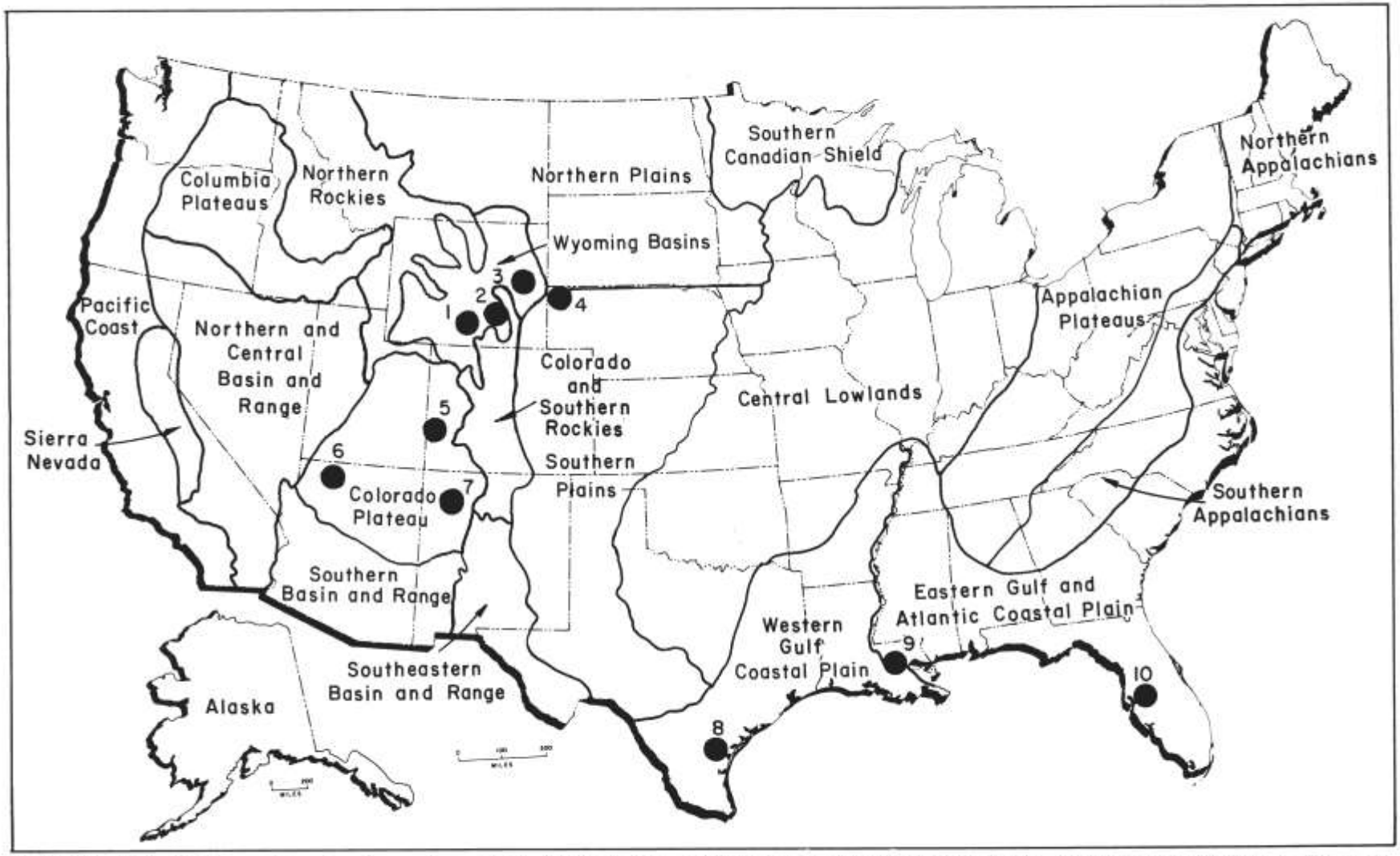

FIGURE 1—United States uranium development areas 1990. (1) Crooks Gap, (2) Shirley Basin, (3) Powder River Basin, (4) Crow Butte, (5) Uravan, (6) Grand Canyon, (7) Grants, (8) South Texas, (9) Freeport, (10) IMC.

Manpower

For many years the DOE has compiled data on employment in the uranium industry. During the boom years of 1978-1990, over 20,000 people were employed in uranium exploration, mining, milling, and processing (U.S. Department of Energy, 1983). In 1989 the Energy Information Administration (1990) counted a total of 1583 people in the industry—exploration 86, mining 659, milling 367, and processing 471. Of the 1583 people counted, New Mexico accounted for only 142 (Energy Information Administration, 1990). This compares to 1978, when nearly 8000 people were employed in the uranium industry in New Mexico (U.S. Department of Energy, 1979). Employment in 1990 was probably near 1300, with New Mexico less than 75.

Regional highlights

Colorado Plateau

The only areas of the Colorado Plateau with ore production in 1990 were the Grants area of northwestern New Mexico (Fig. 1, no. 7), the Uravan area of southwestern Colorado and southeastern Utah (Fig. 1, no. 5), and the Grand Canyon region of northwestern Arizona (Fig. 1, no. 6).

Uranium production in the Grants area of the southern San Juan Basin (Fig. 1, no. 8) declined markedly in 1990. Chevron Resource Co. deep (3200 ft) Mount Taylor underground mine was closed January 12, 1990. This was the last of the underground mines to close in the Ambrosia Lake area, where mining commenced in 1956. The Homestake Mining Co. mill, which processed the Mount Taylor ore, was placed on standby also in January 1990. In May, Chevron announced it was abandoning Mount Taylor and would allow the mine to flood. Chevron has not been successful in finding a buyer for the property. In June 1990 Homestake announced it was no longer going to recover uranium from water circulating through its Section 23 and Section 25 mines which were closed in 1989 and 1981, respectively. By mid-year the only uranium produced in New Mexico was by Rio Algom Mining Corp. which recovered uranium from water circulated through inactive underground mines. This operation has the capacity to produce 200,000 lbs U_30_8 per year.

In the western part of the Grants area, near Gallup, New Mexico, Uranium Resources Inc. continued a solution mining test program on an unmined orebody near the Old Churchrock mine. Between Gallup and Grants, at Crownpoint, New Mexico, Uranium Resources is also testing solution mining. The unmined deposits in the Crownpoint area were discovered by Conoco Inc. in the early 1970s. Permits for commercial operations have been applied for in both areas. In 1990 approximately 300,000 lbs U_30_8 were produced in New Mexico. This represents only 3 % of the total domestic uranium production (Table 6). This is a major decline from the 1970s, when New Mexico annually produced over 40 % of the total United States production (Table 6). Solution mining will no doubt be the uranium industry in New Mexico for the next several years. The host rocks for the uranium deposits in the Grants area are sandstone beds in the Westwater Canyon Member of the Morrison Formation of Jurassic age. The Uravan area of southwestern Colorado and southwestern Utah (Fig. 1, no. 5) contains ore deposits in the Salt Wash

TABLE 6—Uranium concentrate produced in New Mexico, 1971-1990. Mount Taylor ore was processed in Texas. Source: 1971-1987, Energy Information Administration (1990), 1988-1990 estimated.

Year	% of million lbs U_3O_8	U.S. total
1971	10.610	43
1972	10.928	42
1973	9.268	35
1974	9.902	43
1975	10.382	45
1976	12.118	48
1977	13.558	45
1978	17.078	46
1979	14.846	40
1980	15.502	35
1981	12.412	32
1982	7.812	29
1983	5.660	27
1984	2.916	20
1985	1.387	12
1986	0.750[1]	6
1987	0.700[1]	5
1988	2.260	17
1989	2.300	17
1990	0.300	3

Member of the Morrison Formation. In 1990 these ores were more attractive for their vanadium (up to 10 times the uranium) than uranium content. Both elements are recovered at the White Mesa mill. During 1990 the mill received ore from over 20 mines. The average grade of the ore received at the mill was approximately 0.25% U_3O_8 and 1.35% V_2O_5. The largest producer is Umetco Minerals Corp. which operates the LaSal, Sunday, King Solomon, Deremo, and Silver Bell mines. Due to falling vanadium prices and low uranium prices, the White Mesa mill was put on standby in October 1990. It continued to receive ore from independent miners through November, and on January 11, 1991, the Umetco mines were put on standby.

The White Mesa mill of Umetco Minerals and Energy Fuels Nuclear Inc., at Blanding, Utah, alternately processes ores from the Uravan area and the Energy Fuels' breccia-pipe deposits in the Grand Canyon region of northwestern Arizona (Fig. 1, no. 6) The different ores are usually milled in separate six-month cycles. During 1990 Energy Fuels continued mining at the Kanab North mine and development work continued at the Arizona 1 deposit. These mines are on the north rim, with the ore trucked some 300 miles to Blanding. Development of the Canyon deposit, on the south rim, continues to be delayed. All of these ore deposits are in collapsebreccia pipes in sedimentary rocks of Permian and Pennsylvanian age. The grade of ore produced from the breccia pipes ranges from 0.50 to 0.75 % U_3O_8. In January 1991 Energy Fuels closed all of its mining operations in northwestern Arizona.

These small but relatively high-grade breccia-pipe deposits continue to be the target of exploration. During 1990 at least two companies conducted geophysical, geochemical, and drilling programs in the areas both north and south of Grand Canyon National Park.

The White Mesa mill produced an estimated 3.7 million lbs U_3O_8 in 1990. Of this amount, approximately 2.2 million lbs came from the Arizona breccia-pipe deposits.

Wyoming basins

The intermontane basins of Wyoming contain uranium deposits in sandstones of the Wind River, Wasatch, and Battle Spring Formations of Eocene age. Activity in 1989 was limited to Crooks Gap in the northern Great Divide Basin, Shirley Basin, and Powder River Basin.

At Crooks Gap (Fig. 1, no. 1), U.S. Energy Corp. and its subsidiary, the Crested Corp., entered into a restructured joint-venture agreement with the Kennecott Corp. for the development of uranium properties, including the 40 million lb Jackpot deposit. Kennecott provided U.S. Energy and Crested $15 million in the agreement signed in June, and will contribute an additional $50 million for development.

In the Shirley Basin (Fig. 1, no. 2), Pathfinder Mines Corp. ceased milling operations in January, while a new open pit was being stripped. In September 1990 the mill was restarted as ore was again being mined.

In the southern Powder River Basin (Fig. 1, no. 3), Power Resources Inc. continued solution mining at the Highland project. At the nearby Smith Ranch pilot solution mining project, Rio Algom Mining Corp. applied for a commercial license. In the central Powder River Basin, Malapai Resources Co. placed its Irigaray project and its satellite unit at the Willow Creek deposit on standby in February . In September 1990 Malapai was acquired for Fuel International Trading Corp. which is a subsidiary of Societe Auxiliare d'Energy, itself a wholly owned subsidiary of Electricité de France. The transaction also involved Total Minerals Corp., which plans to operate the project beginning in 1992. During 1990 Uranerz USA Inc. received permits from the NRC to solution mine at Ruth and North Butte properties in the central Powder River Basin. In March 1991 these properties were acquired by Pathfinder Mines. Wyoming production in 1990 was approximately 1 million lbs U_3O_8.

Western Gulf Coastal Plain

Uranium deposits in the south Texas coastal plain occur in sandstone beds of several formations, principally the Eocene Whitsett Formation, the Miocene Catahoula Formation and Oakville Sandstone, and the Pliocene Goliad Sand (Figure 1, no. 8).

In the northern part of the area, Chevron Resources Co. (60%) and Total Minerals Corp. (40 %) continued production from the open pit Rhode Ranch mine in McMullen County. The ore, in the Oakville Sandstone, is trucked 80 miles to Chevron's Panna Maria mill near Hobson, Texas. During 1990 Everest Minerals Corp. solution mining plant near Hobson, in Karnes County, was placed on standby.

In the southern part of the area, in Duval County, Malapai Resources put the Holiday-El Mesquite-O'Hern solution mining project on standby in February. As in Wyoming, Malapai's holdings were acquired by the Fuel International Trading Corp. in September 1990. Production in scheduled to resume

in January 1992. Also in Duval County, Uranium Resources Inc. commenced solution mining at the Rosita project in September. This project has the capacity to produce 800,000 lbs U_3O_8 per year. In Kleberg County, Uranium Resources Inc. placed its Kingsville dome solution mining project on standby in April.

Exploration for ore deposits amenable to solution mining continued in south Texas in 1989. Although no new discoveries were announced, development drilling was successful in delineating additional reserves for solution mining operations. During 1990 operations in Texas produced some 2.0 million lbs U_3O_8.

Southern Plains

Ferret Exploration Co. of Nebraska received its final State and EPA permits in April for a commercial solution mining operation at its Crow Butte project in Dawes County, Nebraska (Fig. 1, no. 4). Production will commence in 1991 and could reach a capacity of one million lbs U_3O_8 per year. The uranium deposits in northwestern Nebraska occur as roll-fronts in a sandstone bed in the basal Chadron Formation of the Oligocene White River Group. The grade of the Crow Butte deposit averages 0.25% U_30_8, with a range of 0.05 to 0.50 % U_3O_8 (Pay Dirt, 1991). Ferret continued exploration drilling on the Big Red property which is a southeastern extension of the Crow Butte deposit, and on the Three Cows trend to the west of Crow Butte.

Eastern Gulf and Atlantic Coastal Plain

Uranium, as a by-product of phosphoric-acid production, was produced by the IMC Fertilizer Inc. at New Wales and Plant City, Florida (Fig. 1, no.10). Freeport Uranium Recovery Corp. recovered uranium from Florida phosphate rock, processed at Donaldsonville and Uncle Sam, Louisiana (Fig. 1, no. 9). Freeport entered into a joint venture with Denison Mines Ltd. of Canada for future production from Freeport's by-product plants. Denison provided funding to restart the Sunshine Bridge plant at Donaldsonville, which was closed in 1989. Total uranium production from these by-product operations was about 2.8 million lbs U_3O_8 in 1990.

Foreign highlights

Foreign uranium production in 1990 totaled approximately 65.0 million lbs U_3O_8, down from 85.4 million lbs produced in 1989. With the exception of Namibia, production from all the major countries declined in 1990. Table 7 summarizes the 1990 production. During 1990 the Organisation for Economic Cooperation and Development (OECD) and the Nuclear Energy Agency and the International Atomic Energy Agency (IAEA) published their biannual compilation of uranium activities. This report (OECD et al., 1989) contains exploration, production, and resources data on 43 countries. Since this report contains data gathered in early 1989, the OECD issued a statistical update in mid-1990 (OECD, 1990).

Canada

Whillans (1991) summarized recent developments in Canada. Much of the information presented here is from his report. For the seventh consecutive year, Canada continued to be the leading uranium producer and exporter in the world. In 1990 a total of 22.7 million lbs U_3O_8 were produced, a 23 % decline from the 29.4 million lbs produced in 1989. The uranium produced from the Proterozoic unconformity-type de

TABLE 7-World uranium production in 1990. • Compiled from various sources, including Pool (1991) and Whillans (1991). ** By-Product production from gold and copper mining. * Argentina, Belgium, Brazil, Germany, India, Pakistan, Spain, and Yugoslavia.**

Country	U_3O_8, (million lbs)	Type(s) of deposit(s)
Australia	9.1	Proterozoic unconformity, , Proterozoic stratabound
Canada	22.7	Proterozoicunconformity,quartz-pebbleconglomerate
France	7.4	Vein, sandstone
Gabon	1.8	Vein
Namibia	8.0	Disseminated igneous
Niger	7.4	Sandstone
South Africa**	6.4	Quartz-pebble conglomerate, disseminated igneous
Other countries•• *	2.2	Sandstone, phosphate, disseminated igneous, vein
United States	10.2	Sandstone, phosphate, vein

from Proterozoic quartz-pebble conglomerate deposits of the Elliot Lake area of southern Ontario.

In the southeastern part of the Athabasca Basin, Cameco (A Canadian Mining and Energy Corp.) continued mining the Deilman deposit, producing nearly 13.9 lbs U_3O_8 in concentrate. Key Lake is the largest uranium-production center in the world. At Rabbit Lake in the northeastern part of the basin, Cameco kept its mill on standby due to market conditions. The mill has been idle since July 1989. In the western part of the basin, at Cluff Lake, Cluff Mining Partnership resumed ore processing in February after the mill was shut down in August 1989. The new Dominique-Janine open pit mine supplemented ore being produced from the Dominique-Peter mine, the only underground uranium mine in Saskatchewan. During 1990 production grades ranged from over 0.5 % U_3O_8 at Cluff Lake to over 2 % U_3O_8 at Key Lake (Robert Whillans, pers. comm. 1991).

In the Elliot Lake area of Ontario, Denison Mines Ltd. continued production at its Elliot Lake mine, and Rio Algom Ltd. produced at its Quirke, Panel, and Stanleigh mines. Rio Algom announced in January 1990 that it would close the Quirke and Panel mines in late August 1991. In March 1990 Denison announced the reduction of about 450 workers, effective in August 1990, at its Elliot Lake operations to reduce production by some 37 %. The closures and cutbacks will mean the loss of over 2000 jobs in the Elliot Lake area. Ore mined at Elliot Lake in 1990 averaged 0.08% U_3O_8 (Robert Whillans, pers. comm. 1991).

Cameco sold a one-third interest in its Rabbit Lake operations (including the Collins Bay and Eagle Point South deposits) to Uranerz Exploration and Mining Ltd. in July. Each company now has the same share (Cameco two-thirds, Uranez one-third) in both Key Lake and Rabbit Lake. As Uranerz already owned one-third of the Eagle Point North orebody, the Eagle Point deposit can now be developed as a single underground mine.

The Cigar Lake Mining Co. completed sinking its 1600 ft deep shaft on the Cigar Lake deposit in northeastern Saskatchewan. Development work continued on the 1380 and 1575 ft levels. Cigar Lake, the world's largest and richest uranium deposit, has known geologic reserves exceeding 390 million lbs U_3O_8 in ore grading an average of 12% U_3O_8 (Energy, Mines and Resources Canada, 1989). At Midwest Lake, north of Cigar Lake, Denison Mines completed its test mining program and the mine was allowed to flood. The test mining results have been evaluated and an environmental impact assessment has been prepared.

In the Northwest Territories, near Baker Lake, Urangesellschaft Canada Ltd. requested the federal Environmental Assessment and Review Process panel to delay indefinitely its planned environmental hearing for Kiggavik. Reserves of this Proterozoic unconformity-type deposit are 39 million lbs U_3O_8 in ore grading 0.47 % U_3O_8 (Energy, Mines and Resources Canada, 1989).

Uranium exploration in Canada, mainly in Saskatchewan and in the Northwest Territories, continued at a moderate level. In 1989 about 30 companies spent $58 million (Canadian) on 57 projects (Whillans, 1991). In May 1990 Cameco announced the discovery of the high-grade P2 North deposit at McArthur River, nearly midway between Key Lake and Rabbit Lake. Resources are estimated to exceed 200 million lbs U_3O_8 with an average grade of 4 % U_3O_8 (Whillans, 1991). Joint-venture partners include Cameco 44 %, and Uranerz 29 %.

The National Democratic Party, whose platform calls for phasing out nuclear power, won the Ontario provincial elections in 1990. The impact on Ontario Hydro's substantial nuclear program and on uranium production at Elliot Lake is yet to be determined.

Australia

Australia ranked third in the world in uranium production in 1990 (Table 6). In the East Alligator River area of the Northern Territory, Energy Resources of Australia Ltd. continued production at the Ranger deposits, a Proterozoic unconformity type. The Ranger deposit averages 0.35 % U_3O_8 (OECD et al., 1989). At the Olympic Dam copper- uranium-gold deposit in South Australia, Roxby Down Mining Ltd. (Western Mining Corp. 51%, BP Australia Ltd. 49 %) held back its uranium production and concentrated on copper ore at this huge Proterozoic stratiform-type deposit. Drilled out resources at Olympic Dam are 2.6 billion tons of mineralized material with an average grade of about 1.6 % copper and 0.06 % U_3O_8, and with 0.02 ounces of gold per ton (OECD et al., 1989). Production in 1990 was slightly over 9.1 million lbs U_3O_8, a small decrease from the 9.5 million lbs produced in 1989.

In August, General Atomics purchased the Beverley deposit in South Australia, which contains an estimated 30 million lbs U_3O_8. Previous tests at Beverley indicate that this roll front-type deposit is amenable to solution mining methods. At the end of the year three of Energy Resources of Australia Ltd. major shareholders, North Broken Hill, Cogema, and Rheinbraun acquired a 33 % interest in Pancontinental Mining Ltd., the 65% owner of the large Jabiluka

deposit in the East Alligator River area. Future production from Jabiluka and Beverley is uncertain due to the Australian Labor Party's "three mine" policy. Production is now limited to three approved producers, Nabarlek, Ranger, and Olympic Dam. However, Queensland Mines Ltd. Nabarlek mill closed in 1988, having completed processing all the ore from the open pit mine. The Labor Party has stated its intent to review the three-mine policy but nothing has happened.

Namibia

In Namibia, Rossing Uranium Ltd., a Rio-TintoZinc group company, produces uranium at Rossing, the world's largest open-pit uranium mine. The host rocks are Proterozoic alaskitic granites which contain uranium concentrations averaging 0.03 % U_30_8. Production in 1990 was approximately 8.0 million lbs U_30_8, the same as 1989. Due to free elections and a new government, the United States lifted its political sanctions against Namibia in March 1990. Namibian uranium now will undoubtedly be accepted on the world market.

Republic of South Africa

During 1990 South Africa remained seventh in uranium production (Table 6). Uranium is recovered as a by-product of gold mining, and a small amount, about 200,000 lbs U_30_8, from copper mining at Palabora. Uranium production decreased markedly in 1990, to about 6.4 million lbs U_30_8, down from 7.7 million in 1989. The decrease was primarily due to the closure of Anglo American Corp. uranium-recovery plant at its Freegold gold mine. Further closures are expected in 1991. Weak gold and low uranium prices, plus political sanctions by the United States and other countries against the use of South African gold and uranium, caused the decline in production.

Other countries

Uranium-concentrate production in France declined by about one million lbs U_30_8 in 1990, to 7.4 million lbs U_30_8. Slight declines in production also occurred in Niger and Gabon. Production totalling 2.2 million lbs came from Argentina, Belgium, Brazil, Germany, Pakistan, Portugal, Spain, and Yugoslavia. Pakistan's only uranium mine resumed operations in May 1990, after being closed for four months due to local fighting. Germany and Yugoslavia will terminate uranium production in 1991 due to environmental and economic reasons, respectively. In Brazil production will decline while operations are shifted from the Pocos de Caldas project to the Lagoa Real site.

During 1990 uranium exports from eastern Europe and China totalled 10.7 million lbs U_30_8 (Pool, 1991). The Soviet Union's inventory is more than 400 million lbs U_30_8 (Pool, 1991). Much of this material will no doubt appear on the world market in the coming years.

Outlook

Continued sales from inventories in the Soviet Union, other eastern European countries, and China will continue to keep prices low. Throughout the world, including the United States and Canada, production will continue to decline in 1991, as only low-cost producers can compete in the marketplace. The Uranium Producers of America are currently working with members of Congress on legislation to limit imports and revive the domestic industry. Past efforts in this direction, led by Senator Pete Domenici of New Mexico, have not been successful.

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Selected conversion factors*

TO CONVERT	MULTIPLY BY	TO OBTAIN
Length		
inches, in	2.540	centimeters, cm
feet, ft	3.048×10^{-1}	meters, m
yards, yds	9.144×10^{-1}	m
statute miles, mi	1.609	kilometers, km
fathoms	1.829	m
angstroms, Å	1.0×10^{-8}	cm
Å	1.0×10^{-4}	micrometers, μm
Area		
in^2	6.452	cm^2
ft^2	9.29×10^{-2}	m^2
yds^2	8.361×10^{-1}	m^2
mi^2	2.590	km^2
acres	4.047×10^{3}	m^2
acres	4.047×10^{-1}	hectares, ha
Volume (wet and dry)		
in^3	1.639×10^{1}	cm^3
ft^3	2.832×10^{-2}	m^3
yds^3	7.646×10^{-1}	m^3
fluid ounces	2.957×10^{-2}	liters, l *or* L
quarts	9.463×10^{-1}	l
U.S. gallons, gal	3.785	l
U.S. gal	3.785×10^{-3}	m^3
acre-ft	1.234×10^{3}	m^3
barrels (oil), bbl	1.589×10^{-1}	m^3
Weight, mass		
ounces avoirdupois, avdp	2.8349×10^{1}	grams, gr
troy ounces, oz	3.1103×10^{1}	gr
pounds, lb	4.536×10^{-1}	kilograms, kg
long tons	1.016	metric tons, mt
short tons	9.078×10^{-1}	mt
oz mt^{-1}	3.43×10^{1}	parts per million, ppm
Velocity		
ft sec^{-1} (= ft/sec)	3.048×10^{-1}	m sec^{-1} (= m/sec)
mi hr^{-1}	1.6093	km hr^{-1}
mi hr^{-1}	4.470×10^{-1}	m sec^{-1}

TO CONVERT	MULTIPLY BY	TO OBTAIN
Pressure, stress		
lb in^{-2} (= lb/in^2), psi	7.03×10^{-2}	kg cm^{-2} (= kg/cm^2)
lb in^{-2}	6.804×10^{-2}	atmospheres, atm
lb in^{-2}	6.895×10^{3}	newtons (N)/m^2, N m^{-2}
atm	1.0333	kg cm^{-2}
atm	7.6×10^{2}	mm of Hg (at 0° C)
inches of Hg (at 0° C)	3.453×10^{-2}	kg cm^{-2}
bars, b	1.020	kg cm^{-2}
b	1.0×10^{6}	dynes cm^{-2}
b	9.869×10^{-1}	atm
b	1.0×10^{-1}	megapascals, MPa
Density		
lb in^{-3} (= lb/in^3)	2.768×10^{1}	gr cm^{-3} (= gr/cm^3)
Viscosity		
poises	1.0	gr cm^{-1} sec^{-1} *or* dynes cm^{-2}
Discharge		
U.S. gal min^{-1}, gpm	6.308×10^{-2}	l sec^{-1}
gpm	6.308×10^{-5}	m^3 sec^{-1}
ft^3 sec^{-1}	2.832×10^{-2}	m^3 sec^{-1}
Hydraulic conductivity		
U.S. gal day^{-1} ft^{-2}	4.720×10^{-7}	m sec^{-1}
Permeability		
darcies	9.870×10^{-13}	m^2
Transmissivity		
U.S. gal day^{-1} ft^{-1}	1.438×10^{-7}	m^2 sec^{-1}
U.S. gal min^{-1} ft^{-1}	2.072×10^{-1}	l sec^{-1} m^{-1}
Magnetic field intensity		
gausses	1.0×10^{5}	gammas
Energy, heat		
British thermal units, BTU	2.52×10^{-1}	calories, cal
BTU	1.0758×10^{2}	kilogram-meters, kgm
BTU lb^{-1}	5.56×10^{-1}	cal kg^{-1}
Temperature		
°C + 273	1.0	°K (Kelvin)
°C + 17.78	1.8	°F (Fahrenheit)
°F − 32	5/9	°C (Celsius)

**Divide by* the factor number to reverse conversions.
Exponents: for example 4.047×10^{3} (see acres) = 4,047; 9.29×10^{-2} (see ft^2) = 0.0929.

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