

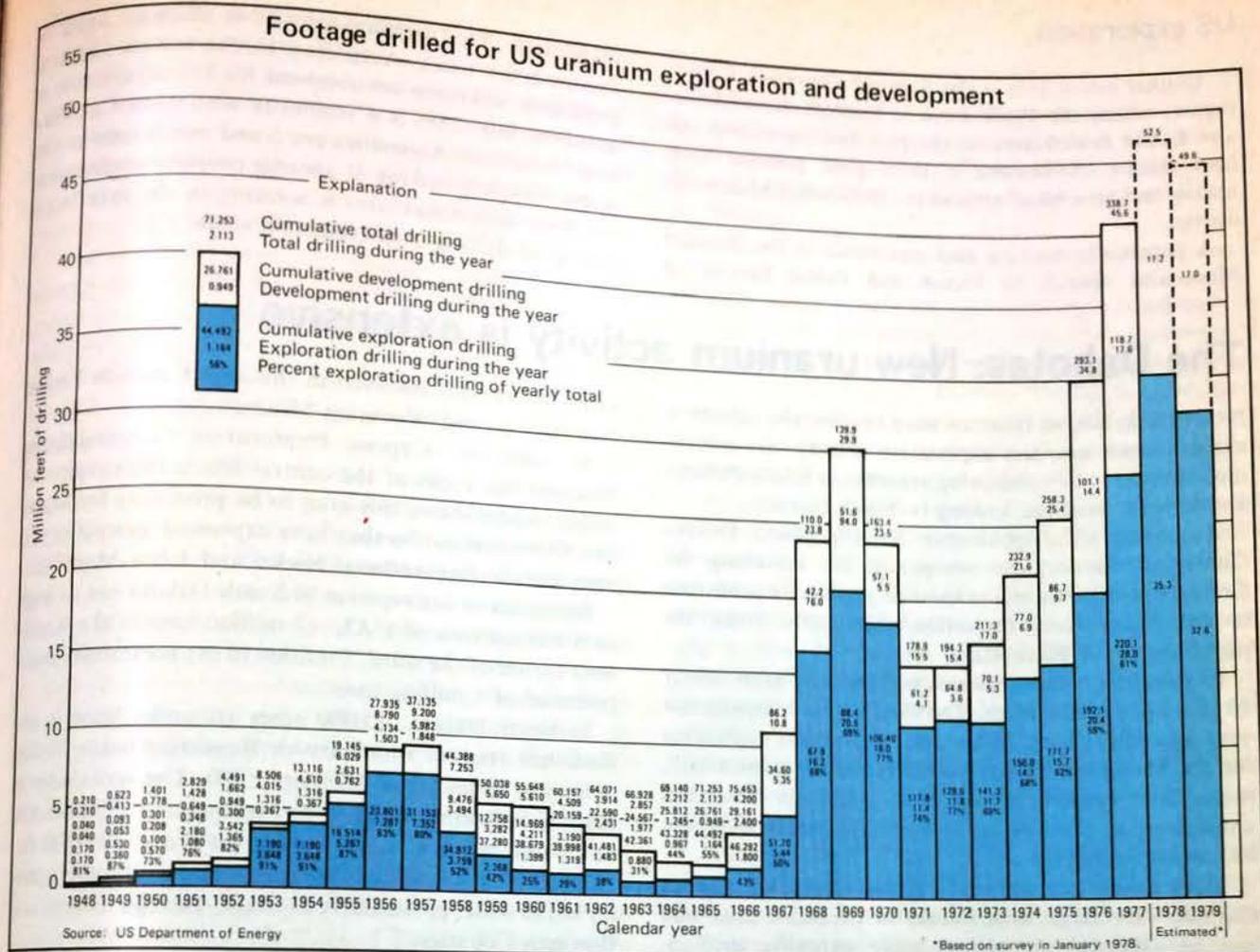
E/MJ

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URANIUM EXPANSION: The rush is on



district to be much greater, perhaps as much as 5 to 10 million lb. In addition, the production shaft initially

planned will serve simultaneously as a conduit for further underground exploration. □

Colorado: Tallahassee Creek is among the big new winners

CYPRUS MINES HAS DISCOVERED what it believes is a potential major roll-front-type uranium deposit in the Tallahassee Creek area of Colorado, about 35 mi north-west of Canon City. The company based its report on the results of exploratory drilling in which 22 holes were sunk and probed. Ore grade mineralization was encountered in nine of the holes. The intersections, varying from 6 to 50 ft thick, graded 0.08% to 0.40% uranium oxide, with an average grade of 0.17%—or about 3½ lb oxide per ton. Drill centers have been widely spaced, ranging from 200 to 1,000 ft, with depth of mineralization averaging 600 ft. Estimated reserves are placed at 30 million lb.

In a related venture, a preliminary letter of intent signed recently by Westinghouse Electric and Cyprus Mines gives Wyoming Mineral Corp. (a Westinghouse subsidiary) a 50% interest in mineral rights on 13,600 acres controlled by Cyprus Mines, including the Tallahassee Creek find. Cyprus would act as operator for any exploration, development, and production.

Elsewhere, the Public Service Co. of Oklahoma has

joined Nuclear Dynamics and Embarcadero Corp. in an extensive three-year uranium exploration and development program centered in western Colorado and eastern Utah. The joint venture controls 20,000 acres of uranium claims and expects to acquire additional properties.

Cotter Corp. and Western Nuclear are exploring extensively in the Front Range district. This area is the site of Cotter's Schwartzwalder mine, one of the largest vein-producing mines in North America.

Rocky Mountain Energy and Denison Mines are drilling in the South Park area of Colorado. In the northern sector of this area, Homestake Mining is performing exploration around the town of Jefferson. Exxon has already come and gone, and Texaco is still looking. Rampart Exploration holds claims here and is said to be looking at mineralization in Tertiary sediments similar to the Tallahassee Creek setting.

In south-central Colorado, at the northern end of Raton Basin, Getty has been drilling in Tertiary sediments. Exxon and Alaska Resources also have claims here.

US exploration

Another active area is the Sawatch-Gunnison County region, where the Pitch mine is located. Kerr-McGee and Exxon drilled here in the past two years and still hold claims. Homestake is in a good position here, having tied up a lot of ground in the Needles Mountains district.

A potentially exciting find was made in the Needles Mountains district by Exxon and Public Service of

Oklahoma. The uranium occurs in siliceous Precambrian rocks. According to one source, this is a previously unknown environment for US uranium, but there is a similarity with some Canadian uranium mines. Anomalies are found over a total of 100 sq mi. Exxon is looking at another property north of this find, and Amax also is working in the area, said to be drilling a molybdenum stock. □

The Dakotas: New uranium activity is extensive

NORTH AND SOUTH DAKOTA have become the targets of extensive new uranium exploration activity. Six companies are said to be conducting searches in South Dakota, and at least three are looking in North Dakota.

According to a spokesman for the South Dakota Geological Survey, the companies are searching for Cretaceous deposits of uranium in permeable sandstone in the Inyan Kara formation, principally along the periphery of the Black Hills.

Exploration in the area resumed recently after nearly 10 years of abandonment. The most active company last year was Silver King Mines Inc., a uranium contractor for the Tennessee Valley Authority, which owns a mill, mines, and property in the area. Although TVA has announced no plans as yet, Silver King seems to be the closest to production.

Two other companies—Mobil Oil and Union Carbide—are large leaseholders in the same area and can be expected to conduct more extensive drilling.

Other companies involved in the search include Exxon, Nokota Co., and Wyoming Mineral.

In addition, Cyprus Exploration is prospecting Precambrian rocks of the central Black Hills region. A recent report shows this area to be promising for uranium. Other companies that have expressed interest in the area include International Nickel and Johns-Manville.

Estimates of ore reserves in South Dakota run as high as 8 million tons of U_3O_8 —2 million tons in the southwest corner of the state, 5 million in the northwest, and a potential of 1 million tons.

In North Dakota, 40,000 acres are under lease in the Badlands area, of which Power Resources holds 20,000 acres and Homestake Mining, 2,560. The remainder is held by individuals said to be representing Felmom Co. Co. These companies are looking for ore at 300-500 ft.

North Dakota officials expect a good deal more activity in the state, particularly in Stark, Billings, Slope, and Bowman Counties. □

Minnesota: Action heats up in the north

THE NORTHERN SECTION of Minnesota is the arena of an intense search by uranium exploration companies, according to a spokesman for Martin-Trost Associates, one of the firms active in the region. Two other companies, Rocky Mountain Energy and Energy Resources Group, also have launched major efforts in the state.

The search in Minnesota focuses on a broad belt, more than 20 mi wide, extending southwest from Duluth to Denham. The companies have leased more than 35,000 acres and are leasing additional land in the vicinity of Barnum and Mahtowa in southwestern Carlton County and around Denham in northwestern Pine County. Aitkin and St. Louis Counties also are targets.

The geological characteristics of this region are likened to the environment in the Athabasca Basin of Saskatchewan, Canada, where major uranium deposits have been discovered in the Cluff Lake, Key Lake, and Rabbit Lake areas.

Rocky Mountain Energy and Mono Power are

conducting a joint venture in Minnesota. Rocky Mountain operated two drill rigs last fall and winter in Carlton County to obtain core samples. Thirty-eight test holes, 500 to 600 ft deep, were drilled, but a company spokesman said nothing of significance was found.

However, occurrences of "diffuse uranium" were discovered, and plans have been made to continue exploration in the Carlton County section over the next three years. Rocky Mountain also is conducting geological reconnaissance and is collecting data in several other Minnesota districts encompassing "several hundred square miles," a spokesman said.

Energy Reserves Group began operating two drill rigs last spring but suspended operations until this fall because of wet ground conditions. The company, which has leased 11,000 acres around Denham, said no uranium deposits were found in its drilling. Kerr-McGee reported that it is "very interested" in the region and is continuing an active exploration program. □

New Mexico: Grants uranium belt is still number one

FUTURE INCREASES IN US PRODUCTION of uranium oxide depend largely on development activity in two key

states—New Mexico and Wyoming. In 1977, 4.2 million tons of uranium ore were mined and processed in New Mexico. □

Mexico, yielding 7,500 tons of U_3O_8 , or 49% of the nation's oxide production.

The 25 companies involved in exploration and development work in northwestern New Mexico have created a uranium boom. The companies are operating 30 to 40 exploration drilling rigs and 30 to 35 development rigs, in addition to exploration work recently begun on the Navajo Indian Reservation.

A major agreement for uranium exploration and development signed by Exxon Corp. with the Navajo nation gives Exxon the right to explore for uranium in a 400,000-acre tract on the Navajo Reservation in San Juan County, N. Mex. If ore is found in quantities that warrant development, Exxon is authorized to lease a total of 51,200 acres for mining purposes. The term of the prospecting permit is two years, with automatic extensions of two successive two-year periods.

Other significant exploration in New Mexico includes drilling by Atlantic Richfield in the Chama Embayment east of Canjilon; work under way by Union Carbide in the Hagan Basin, northeast of Albuquerque; and drilling by Gulf Mineral Resources in Catron County.

But the major area of uranium activity in the state is the Grants mineral belt, which is being widened as mining companies move farther downdip and go to greater depths to extract ore from the Morrison formation. Exxon has been conducting exploration drilling just south of Star Lake, where the Morrison formation may lie at depths as great as 4,000 ft.

Within the Grants belt, Conoco is drilling on the northeastern part of the Laguna Indian Reservation to depths of about 2,000 ft, while Homestake Mining is drilling 1,000-ft holes about 8 mi west-northwest of Conoco, and Bokum Resources is sinking holes 2,000 to 3,000 ft deep, about 4 mi south of Santa Rosa Peaks.

South-southwest of Bokum Resources, Sohio is drilling land about 2 mi northeast of Moquino, at 1,000- to 2,000-ft depths. Other companies active in drilling include: Anaconda, south of Paguete (1,000-ft holes); Energy Fuels, about 10 mi west of Anaconda (2,000 ft); Exxon, about 6 mi east of Mt. Taylor (deeper than 4,000 ft); and Gulf, about 8 mi north of Mt. Taylor (2,000 to 5,000 ft).

West of Gulf's prospect, the field gets crowded. Homestake is drilling on San Mateo Mesa and, with United Nuclear, at Ambrosia Lake, about 10 mi west.

Pacific Northwest: Setting the stage for more finds

EXPLORATION IN WASHINGTON state has zeroed in on uranium in the Pend Oreille Valley and in southwest Stevens County, near the Midnite uranium mine. Companies working in the Pend Oreille Valley include BurWest, Conoco, Exxon, Minatome, US Steel, Denison Mines, and Reserve Oil. West of this area, in eastern Ferry County, at least five companies are exploring.

At the site of its Midnite mine, Dawn Mining has completed several new drillholes. Meanwhile, Rex-Con is exploring in northern Lincoln County, about 12 mi

Acknowledgement: E/MJ thanks A. E. Saucier, consulting geologist and president of Sedi-Met Inc., P.O. Box 827, Cedar Crest, N. Mex., for his contributions on uranium exploration in New Mexico.

Depths range from 1,000 to 2,000 ft. Kerradamex is sinking 1,000- to 2,000-ft holes about 3 mi southwest of San Mateo, in Tinaja Arroyo, and 2,000- to 3,000-ft holes 8 mi to the north. Frontier Mining is exploring a sizable area that partially overlaps the Kerradamex prospect. Houston Oil is drilling to depths of 2,000 to 3,000 ft 5 mi southeast of the Kerradamex prospect.

Besides Homestake, other companies active in the Ambrosia Lake area include Kerr-McGee and Cobb Nuclear. Kerr-McGee is also exploring approximately 6 mi east of its Ambrosia Lake drill site. Ranchers Exploration, the Santa Fe Railroad, and Todilto are prospecting at Mesa Montanosa. Pathfinder Mines is drilling at two sites, 4 mi and 8 mi northwest of Ambrosia Lake, to depths of 1,000 to 2,000 ft. Gulf is also drilling in this vicinity.

Ranchers, Homestake, and Gulf are exploring near Casamero Lake, while Gulf and Western Nuclear are drilling at Smith Lake.

Ranchers, Gulf, Arco, Pioneer Nuclear, Teton, Pathfinder, Conoco, and Mobil are sinking drillholes along a line stretching from Pinedale in the southwest to Chaco Canyon National Monument and Crownpoint in the northeast. At drill sites approximately 6 mi northwest of Crownpoint, both Mobil Oil and United Nuclear are sinking 2,000- to 3,000-ft holes. Homestake, Uranium King, and Teton are drilling 2 to 4 mi north of Springstead, while United Nuclear and Kerr-McGee are probing areas north and northeast of Teton, respectively.

Phillips Petroleum is sinking 4,000-ft holes in an area 8 to 10 mi north-northwest of Seven Lakes. Also along the outlying edge of the Grants mineral belt, Teton is exploring a wide area southeast of Torreon and northeast of San Luis. At Mesa Portales, even farther downdip from the mineral belt, New Cinch recently completed 60 holes and has outlined an estimated 6.6 million lb of U_3O_8 . The low-grade zone is 9,000 ft long and 3,000 ft wide. □

southwest of the Midnite mine.

In other parts of the state, Energy Resources is said to be drilling at the old Daybreak mine on the western flanks of Mount Spokane, while Houston Oil and Mineral Corp. has sunk drillholes in the Mount Leona area in east-central Ferry County. In the Sultan Basin of Snohomish County, several companies are known to be exploring for uranium, while to the north, Pathfinder Mines has been searching for uranium hosts.

In Stevens County, an unnamed "major" uranium

US exploration

mining firm has leased 17 mining claims from Empire Explorations Inc. Western Nuclear's work on the 165-acre Gillis lease, adjoining the Midnite mine on the east, has indicated a probable reserve of 15,000 lb of U_3O_8 and a potential for 2 million lb. Average grade encountered in 14 drillholes was 0.15% U_3O_8 , or 3 lb per ton.

Within the Spokane Indian Reservation, North Star Uranium has acquired uranium prospecting permits on 1,866 acres, and Century 21 Mining has picked up 1,600 acres of permits. The permit area is about 1 mi east of the Midnite mine. Dension Mines (US) is undertaking a uranium exploration program on more than 3,200 acres of prospecting permits held by Quad Metals on the Spokane Indian Reservation.

In Montana, Exxon continues an exploration drilling program for subsurface Tertiary uranium deposits in the Townsend Valley, Broadwater County. St. Joe American is investigating Tertiary rocks in Lewis and Clark and Broadwater Counties.

The Department of Energy (DOE) has issued a report, "Preliminary Study of Uranium Favorability of the

Boulder Batholith, Montana," giving results of a study of plutonic rocks of the batholith and younger rocks that overlie the structure.

In west-central Montana, parts of the Elkhorn Wilderness study area appear to have possible resources of uranium and thorium.

DOE has released the results of an investigation of low-grade uranium occurrences in rocks of the Idaho batholith near radioactive placers in Bear Valley and Boise and Valley Counties. Entitled "Provenance of Radioactive Placers, Big Meadow Area, Valley and Boise Counties, Idaho," the report is on open file in the US Geological Survey's Spokane, Wash., office.

In the Lakeview area of Oregon, in Lake County, several companies have been looking for uranium. Pacific Finder Mines has explored claims of Utah International. Polaris Resources, a consulting firm, is doing an evaluation for Urania Inc. Western Nuclear, which holds the White King and Lucky Lass properties, has been actively exploring. Exxon, which staked a large group of claims in 1976, has since relinquished most of them.

Texas: The third-ranking state in uranium reserves

TEXAS IS THIRD AMONG STATES in tonnage of uranium reserves, and exploration in the state has been substantial. In addition to Conoco, which is exploring near its Conquista project, several other companies are aggressively searching for uranium in southern Texas.

Exxon is rehabilitating a mine in Live Oak County, and Chevron USA has started work on a mine in Karnes County. E&B Explorations Ltd. of Calgary, Alta., acting on behalf of the West German firm Sedimex, has entered into two joint venture pacts. In the Gulf Coast area, E&B and Intercontinental Energy Corp. (IEC) plan a five-phase exploration program totaling \$7.5

million, to be conducted from 1978 to 1982.

Intercontinental Energy also has agreed with Baltimore Gas and Electric (BG&E) to explore for uranium on 17,000 acres of IEC leases and options in Bee, Live Oak, and McMullen Counties. IEC has started the first phase, consisting of about 220,000 ft of drilling.

The University of Texas will provide a geologic and geochemical evaluation of the uranium potential of the Catahoula formation in Texas. The university also says that significant amounts of uranium appear to exist in the west Texas counties of El Paso, Hudspeth, Presidio, Brewster, Jeff Davis, and Culberson. □

Utah: Heavy search efforts are paying off

THE FREEWAY AND FERRON GROUPS of uranium claims—13,420 acres in Emery County—have been acquired by Mountain States Resources from private holders. The company is looking for joint venture partners to develop the properties.

Idaho Mining has signed a lease and option-to-purchase agreement for 50 uranium claims owned by Geo-Energy Resources in San Juan County.

Hecla Mining and Union Carbide have obtained "favorable" results from second-phase drilling on the Lisbon Valley uranium-vanadium prospect. Union Carbide plans development drilling late this year.

A recent US Geological Survey report says the potential is "excellent" for discovery of ore deposits in the Tushar Mountains of Utah. USGS geologists believe that deposits of minerals, including uranium, may be zoned around a deeply buried dome in the Deer Trail Mountain-Alunite Ridge area of Piute County. The

study is part of a larger USGS program to evaluate the mineral potential of an 8,120-sq-mi area of Utah that includes all of Beaver County and parts of Piute, Iron, Garfield, Sevier, and Millard Counties.

Mineral Energy (MEI) and Pechiney Ugine Kuhlmann Development have signed a joint operating pact under which Minatome, represented by Pechiney, will explore and develop all of MEI's uranium properties in southern Utah not affected by prior agreements with other companies. Mineral Energy also has signed an agreement with Emery Uranium to explore for uranium on 100,000 acres in southeastern Utah.

Polaris Resources and Geosurveys say that their joint uranium exploration program with Energy Fuels in the Topaz Mountain area of Utah has led to a discovery in a volcanic formation. Drillholes revealed deposits ranging from 0.05% to 0.28% uranium oxide.

Energy Resources has purchased additional mining

claims adjacent to its uranium property near Blanding, bringing its holdings in this area to 42,000 acres. The company has also secured options to buy 15,000 acres of potential uranium property in the area.

More recently, the Bureau of Land Management, in compiling an inventory of wilderness areas, sharply curtailed uranium exploration by two companies in the Dirty Devil River region of Utah's canyonlands. Cotter Corp. and Anschutz have been asked by the BLM to stop building roads in certain roadless areas that are considered by the agency to have wilderness characteristics. The restrictions will affect an area 20 mi east and southeast of Hanksville in eastern Wayne County.

Other companies operating in southeastern Utah, now

the center of intense exploration activity, have not yet been seriously affected by the BLM action. Gulf Mineral Resources and Phillips Uranium both say their claims are bisected by existing roads, thereby exempting them from the wilderness inventory.

Although Gulf dropped plans to construct 5 mi of roads on the Mancos Mesa, along the eastern shore of Lake Powell, a spokesman said the decision to halt road building had no serious impact on Gulf's exploration.

Meanwhile, to the north of Gulf's claims, in sand dune country of the San Rafael Swell, Sunshine Mining will soon begin exploring for uranium on two tracts covering 36,000 acres. The company, however, does not anticipate any conflict with BLM activity. □

Wyoming: Exploration moves ahead at full steam

EXPLORATION in Wyoming continues at a fast pace despite all the red tape generated by state agencies. Footage drilled in 1978 is expected to top all previous years—at an estimated total of more than 17 million ft. Footage drilled in 1977 amounted to 15.4 million ft, or 37.6% of all drilling in the US.

The major exploration and development effort in the state continues to be directed toward sandstone environments, especially within the major producing districts. Large petroleum companies lead the drilling activities, followed by smaller petroleum and mining companies and independent operators. In general, drilling depths are increasing and ore grades are falling. However, significant exploration successes are being achieved.

The scramble is on for uranium reserves in the Powder River Basin and elsewhere in Wyoming. St. Clair Energy Corp., owned by Detroit Edison, has bought 51% of mining claims and uranium leases covering 71,000 acres in Johnson County from Western Kaycee, a limited partnership of Western Standard.

Mineral Resources Development Inc. (MRD) holds uranium mining deeds for the Dike claims in the Powder River Basin with Kerr-McGee, the Pot and Millie claims with Rocky Mountain Energy (RME) on Copper Mountain, the Steve claims with RME in the Pedro Mountains of Shirley Basin, the Ketchum Buttes project in Carbon County with Gulf Minerals and Cabot, and the Cyclone Ridge Jim and Cap claims with RME.

The Kimberley group of claims in Crooks Gap has been under option to Kerr-McGee for four years. MRD is actively exploring in Crooks Gap, Red Desert, Copper Mountain, Lysite Mountain, Gas Hills, Shirley Basin, Powder River Basin, and South Pass.

Nuclear Power & Energy Co. (Nupec) has agreed to acquire varying mineral interests and royalties in mining claims and leases acquired by Modern Mining & Milling Co. Inc. from Romco Inc. The lands are in the Gas Hills area, the Pryor Mountain area, and the Copper Mountain area.

Starting in December 1976, Gulf Mineral Resources completed more than 50,000 ft of drilling on Nupec's Deer Creek claims, in Fremont County's Wind River

Basin. Gulf has not released drilling results, but uranium mineralization of sufficient grade and thickness to contain about 500,000 lb of U_3O_8 had reportedly been delineated less than 1,000 ft from Nupec's property line. Gulf is also exploring 939 other claims leased from Nupec, which owns an additional 20,000 acres of claims in the Gas Hills.

Pioneer Nuclear Inc. (PNI) holds a substantial interest in more than 265,400 acres of leases and claims in Wyoming on which a number of uranium deposits and prospects with substantial reserves of economic value have been developed. The 1977 drilling program increased PNI's resources in the state by more than 25%. While PNI plans no production in Wyoming in 1978, it anticipates starting baseline studies on one project this year. In addition, a discovery made in the Crooks Gap district in 1977 will be explored with PNI's joint venture partners.

American Nuclear Corp.'s exploration department is active on the Christensen Ranch in the Powder River Basin, consisting of 28,875 acres. This huge acreage is owned 50% by John Wold, through J&P Corp., 25% by Western Nuclear, and 25% by American Nuclear.

Homestake Mining Co., in cooperation with an eastern utility company, is completing the third year of a four-year exploration and development program at its Hauber property in northeastern Wyoming. The 55,000-acre property reportedly is closer to production than any other Homestake uranium holdings in the area.

In southern Wyoming, BG&E has joined Philadelphia Electric, Pennsylvania Power and Light, and Public Service Electric and Gas Co. of New Jersey in a joint exploration venture in the counties of Albany, Carbon, and Sweetwater. The search area covers 30,000 acres.

American Nuclear and its joint venture partner Tennessee Valley Authority plan substantial expenditure in 1979 to define uranium reserves in the Brown Ranch area of the Powder River Basin.

Agip Mining, the US subsidiary of Italy's government-owned energy company, ENI, has contracted David Robertson Associates to survey uranium claims in the Gas Hills district. □

A stretch of desert along Route 66—the Grants belt—is chief locale for US uranium

Richard Hoppe, Senior editor

AT THE END OF WORLD WAR II, one of the most popular songs noted that you could "get your kicks on Route 66," and went on to list all the towns between Chicago and L.A. where this ostensibly could be done. Gallup was the only place in New Mexico mentioned in the song—one presumably whizzed past the town of Grants at whatever was the legal speed limit. Then, in 1950, Grants got on the map in a big way when a Navaho sheepherder, Paddy Martinez, called attention to indications of uranium deposits that were to make the Grants district the largest center of uranium mining in the US. The Grants uranium belt, some 25 mi wide, runs north of Route 66, from just west of Albuquerque to just east of Gallup. Nearly half of the uranium oxide produced in the US comes from ore mined in the district.

Since 1951, when mining began in the district, production of ore has totaled 55 million tons averaging 0.21% U₃O₈. In 1977, US production of uranium oxide amounted to 14,900 tons—of which 6,800 tons came from the Grants belt.

After a slump in uranium prices during the 1960s and early '70s, the uranium boom is on again and Grants is once more the center of major mine-mill expansion and the exploration for, and development of, new mines. More than 5,000 are now employed in such activities around the Grants belt, and the trailers keep arriving. The companies sorely need skilled underground workers with good mining experience in wet, weak rock conditions where ore appears and disappears with maddening irregularity.

Most of the ore deposits in the Grants belt occur in sedimentary rocks of several ages, principally the Todilto limestone, the Morrison formation, and Dakota sandstone. A great variety of uranium minerals, both oxidized and unoxidized, occur in the strata, which generally are water-bearing. Most mines are underground, and production from a single mine is relatively small—500 to 1,500 tpd.

There is some activity in New Mexico outside the Grants belt: Atlantic Richfield is drilling east of Canjilon, Union Carbide northeast of Albuquerque, and Gulf Mineral Resources in Catron County. But the Grants district is the area of greatest activity, as mining companies move down dip in the Morrison formation for deeper ore.

Bokum Resources Corp. is driving a 2,150-ft-deep shaft 35 mi northeast of Grants in preparation for mining in 1979; Phillips Petroleum Co. will soon be mining 3,400 ft deep at Nose Rock; Exxon has been conducting exploration south of Star Lake at depths to 4,000 ft; and Mobil, Gulf, and Conoco are at or near the development stage.

The surge in uranium prices from less than \$10 per lb to more than \$40 has created the boom—and a new latitude in what is considered ore. Old-timers realize that the boom could reverse itself. It's happened before. In addition, the economics of mining depend on overcoming numerous problems caused by the distinctive features of the deposits—including erratic mineralization, ground water, incompetent ground, and radiation.

Most of the underground mines are in water-bearing sandstones, requiring extensive ground support. Wet conditions inhibit productivity and require costly outlays for underground sumps, drainage systems, pump stations, and piping. The water is abrasive because of the contained fine sands, and as the mines go deeper, hot water is the rule. Depletion of the ground waters is also a source of conflict with local farmers, ranchers, and Indian tribes.

Extraordinary amounts of fresh air ventilation are required to reduce hazards of radiation from radon gas and its decay products (radon daughters), which are set loose in the air as mining proceeds. State and Federal

Companies active in northwestern New Mexico

Anaconda Co.	Pathfinder Mines Corp.
Atlantic Richfield Co.	M&M Mining Co.
Bokum Resources	Mobil Oil Co.
Cobb Nuclear Corp.	Musto-Canorex
Continental Oil Co.	Phillips Petroleum Co.
Energy Fuels Co.	Pioneer Nuclear Inc.
Exxon Co. USA	Ranchers Exploration & Development Corp.
Farris Mines	Reserve Oil & Minerals Corp.
Frontier Mining Corp.	Sohio Petroleum Co.
Getty Oil Co.	Teton Exploration Drilling Co. Inc.
Gulf Mineral Resources Co.	Todilto Exploration & Development Corp.
Homestake Mining Co.	Union Carbide Corp.
Houston Oil & Minerals	United Nuclear Corp.
Keradamex Inc.	Western Nuclear Inc.
Kerr-McGee Corp.	Ray Williams Mining

Uranium production facilities in Grants region

Company	Mill capacity (tpd)		
	1978	1979	1980
Anaconda	4,600	6,000	6,000
Kerr-McGee Corp.	7,000	7,000	7,000
United Nuclear-Homestake Partners	3,400	3,400	3,400
Reserve Oil & Minerals-Sohio	1,600	1,600	1,600
United Nuclear Corp. (Church Rock)	2,000	2,000	2,000
Gulf Mineral Resources Co.	—	—	2,500*
Bokum Resources Corp.	—	1,000	2,000
Totals	18,600	21,000	24,500

*Design capacity 5,000 tpd.



Calweld blindhole raise borer develops 54-in.-dia holes while automatically sending muck to cars.

ventilation stream, and each worker's exposure to radiation is monitored. The maximum number of radiation exposure units per worker over a specified time is set by law.

Four main centrifugal fans with backward-curving impellers, driven by 400-hp motors, are in place over four 60-in.-dia cased boreholes to exhaust the air. They are backed up by four spare 125-hp axial-vane fans.

Fresh air is downcast—induced—through the main shaft and two supplementary 60-in.-dia ventilation holes. Underground, 106 auxiliary and spare fans, ranging from 3 to 40 hp, are placed about the openings.

All mine water is directed by gravity ditches, drain holes, and collection systems and discharged to the lowest level of the mine.

The bottom level of the mine has a small sump in the shaft and two main collection sumps 10 ft deep and measuring 12 x 150 ft. Each day, one collection sump is in use while the other is being cleared of sands and detritus—about 600 cu ft per day of waste. (The material is hoisted to the surface for waste disposal.)

Water from either of the two bottom sumps spills over a weir into a clear well connected to the lower level pumping station. The station is equipped with three Hazleton 10-in. HN-VN vertical centrifugal pumps driven by 250-hp electric motors. Two of the pumps are in use and together can handle 4,000 gpm. The third unit is on standby. The water is pumped from this station to a sump at elevation 1,640.

The sump at level 1,640 is 12 ft deep and measures 12

x 105 ft. The station is equipped so that all water from this level can be pumped to the surface by two separate systems. In the first system, four 500-hp, five-piston Aldridge reciprocating pumps, with a total 4,000-gpm capacity, pump water directly to the surface. In the second system, two A-S-H C5 200-hp centrifugal pumps are used to move 4,000 gpm to level 1,250, where four A-S-H C5 250-hp centrifugal pumps move the water to the surface.

Within the production shaft, each of the 14-in.-dia pump columns is independent of the other, one used for the A-S-H system, the other for the Aldridge. Either, however, can be switched over to the other system. As added insurance against flooding, another bored and cased hole, 16-in. in diameter, can be used should the shaft lines be down.

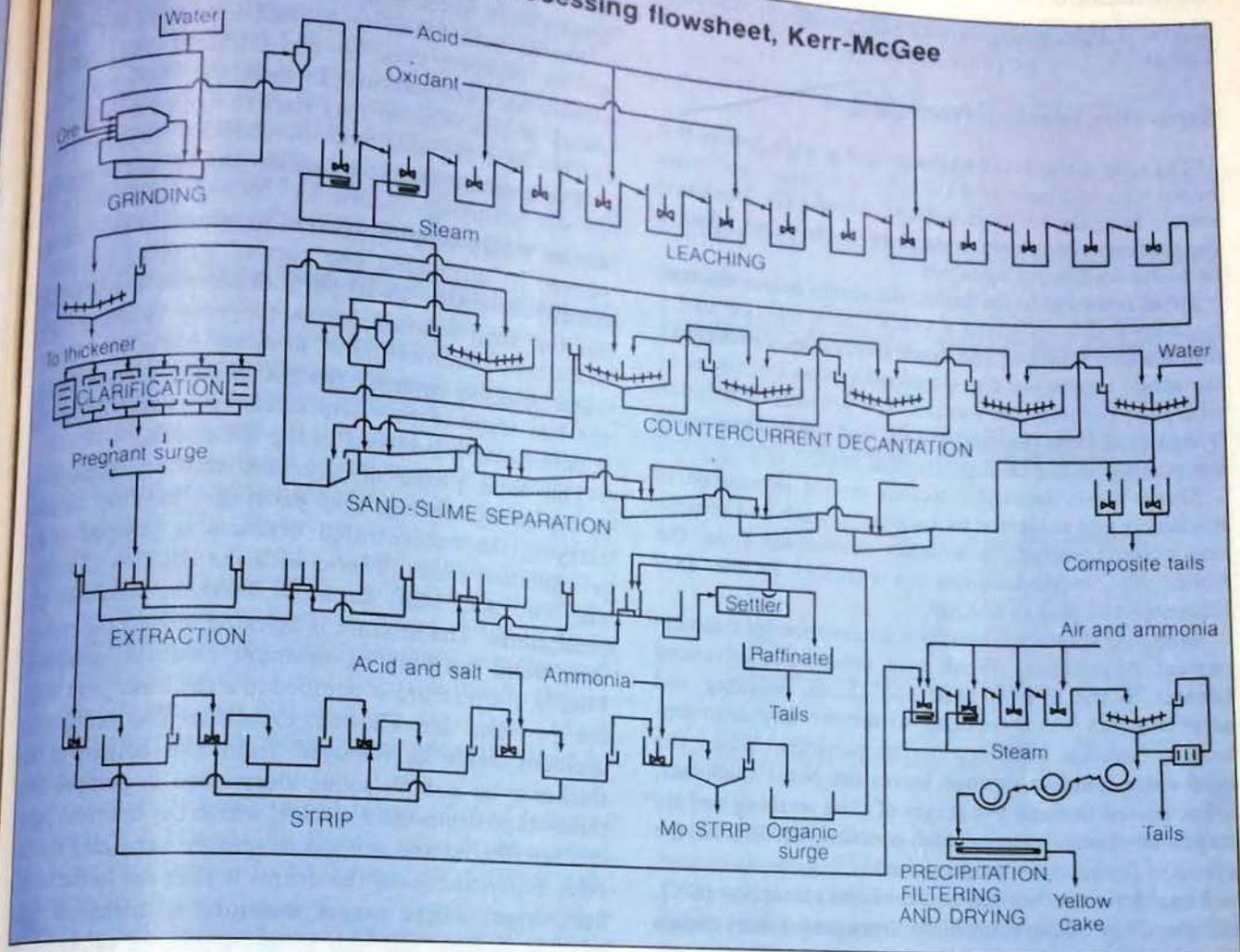
All mine water brought to the surface is treated with flocculant and barium chloride to remove slimes and radium. The water is then directed to two further settling ponds and is ultimately discharged into a nearby arroyo.

The mill at Ambrosia Lake

Ore from Church Rock, from eight other Kerr-McGee mines, and from several toll shippers is trucked to the Kerr-McGee mill at Ambrosia Lake, about 25 mi north of Grants.

The name Ambrosia Lake may be derived from desert humor. No body of water has existed there in living

Uranium ore processing flowsheet, Kerr-McGee



memory and it's doubtful that lake water in the region could have ever tasted like ambrosia—save perhaps to someone expiring from thirst. In the 1950s, the region became famous as the center of uranium mining in the US. The Kerr-McGee mill was completed in 1958 at a cost of \$19 million—a pittance nowadays—and is the largest yellowcake mill in the US. The recovery efficiency of the acid leach facility remains well over 90%. The plant was built by Stearns-Rogers, and new mills today follow the basic design of this plant—deviating mainly in refinements of control procedures and apparatus. Currently, the mill is undergoing modifications costing more than \$1 million.

At the mill scalehouse, each truckload of ore is weighed, and a sample is taken to determine moisture content. (Feed to the mill is calculated in dry-ton equivalents.) The ore is then trucked and discharged at one of 16 1,000-ton-capacity ore storage pockets.

Current feed rate to the mill averages 6,200 tpd at an average grade of 0.20% U_3O_8 . Yellowcake product, in 55-gal drums averaging 80-83% U_3O_8 amounts to 28,000 lb per day. Byproduct output of crude molybdenum amounts to 75,000 lb per year.

Some 190 salaried and hourly employees keep the mill running seven days a week, 49 weeks a year. The mill is

shut down each summer for three weeks for acid plant turnaround and mill maintenance.

Yellowcake produced from Kerr-McGee ore is sent to the company's refining plant in Sequoyah, Okla., for conversion to UF_6 . Alternately, the yellowcake may be shipped to the Eldorado Nuclear plant in Port Hope, Ont., or to the British Nuclear Fuels facility in Great Britain. Refined UF_6 is normally sent to enrichment plants of the US government.

Preparing ore for chemical treatment

From the receiving pockets, ore is front-end loaded onto a feeder to the primary crusher, reduced to minus 4 in. in size, and conveyed to the secondary crusher, where it is reduced to minus 1 in. The ore is then passed through an automatic sampling tower. From an initial lot of 2,000 tons, the sampler takes 200 lb, which is reduced manually to 6 oz. The sample is assayed and the remainder is returned to the ore stream, which fills a series of fine ore bins that are used for both surge and blending.

Blended ore from the bins is fed to two parallel circuits in the mill. Rod mills grinding with water reduce the feed to minus 28 mesh. The ore, in a 50% solids

Wyoming approaches New Mexico in U₃O₈ production and reserves

Dan Jackson, Western editor

WYOMING'S URANIUM INDUSTRY is expanding rapidly, putting the state in a close race with New Mexico for first place in ore reserves, mine production, and milling capacity. Although the uranium bonanza in Wyoming began just 25 years ago, the state now supplies about 40% of all uranium used in the US, and its production is outranked only by New Mexico's. The two states alone hold 83% of the nation's uranium reserves producible at a cost of \$50 per lb of U₃O₈, with Wyoming's share of the total estimated at about 35%.

The uncertainties clouding the future of the nuclear power industry have not slowed uranium development in Wyoming, where a dramatic surge in mining and milling activities is under way. Production in 1977 totaled 3.7 million tons of ore and 5,000 tons of yellowcake, according to the Department of Energy. This compares with 2.5 million tons of ore and 3,700 tons of U₃O₈ in 1975, when the industry really began to take off. Production is expected to double in the next five years and to triple by the late 1980s, and exploration is slated to set new records in footage drilled in 1978.

Milling capacity exceeds 14,000 tpd—a new high. Within the past several months, a number of companies have announced plans to open new mines and construct mills. If followed through to completion, these plans

would push the state's total milling capacity over the 20,000-tpd mark by 1980.

The severance tax on uranium produced in the state comes out of the ground, but Governor Ed Herschler is talking about an increase in the mineral tax. It is reported that the governor, forewarned by California Proposition 13, may increase the mineral tax to offset a possible decrease in property taxes.

Uranium has been found in rock of virtually every geological age in Wyoming, even in some streams. But the most important economic deposits discovered to date are in permeable sandstones of Tertiary age. Most geologists agree that the major contributing source of uranium was Precambrian crystalline rock forming the cores of mountain ranges. Additional radioactive material undoubtedly was supplied by volcanic ash that covered the state during more recent geological periods. Uranium was leached from these source rocks and precipitated in sandstones of much younger age. The major uranium districts in the state are located in areas where the once-dispersed uranium is concentrated along reef fronts.

Recently, discovery of possible economic uranium deposits in rock of Precambrian age in the Sierra Madre and Medicine Bow mountains has stimulated interest in the search for uranium in other parts of Wyoming, according to a report released by the US Geological Survey.

Although there are no other producing uranium deposits or reserves of this type in the US, a USGS spokesman said, deposits in two of the world's largest uranium-producing areas—Blind River in Ontario and the Witwatersrand in South Africa—are found in similar quartz-pebble conglomerates.

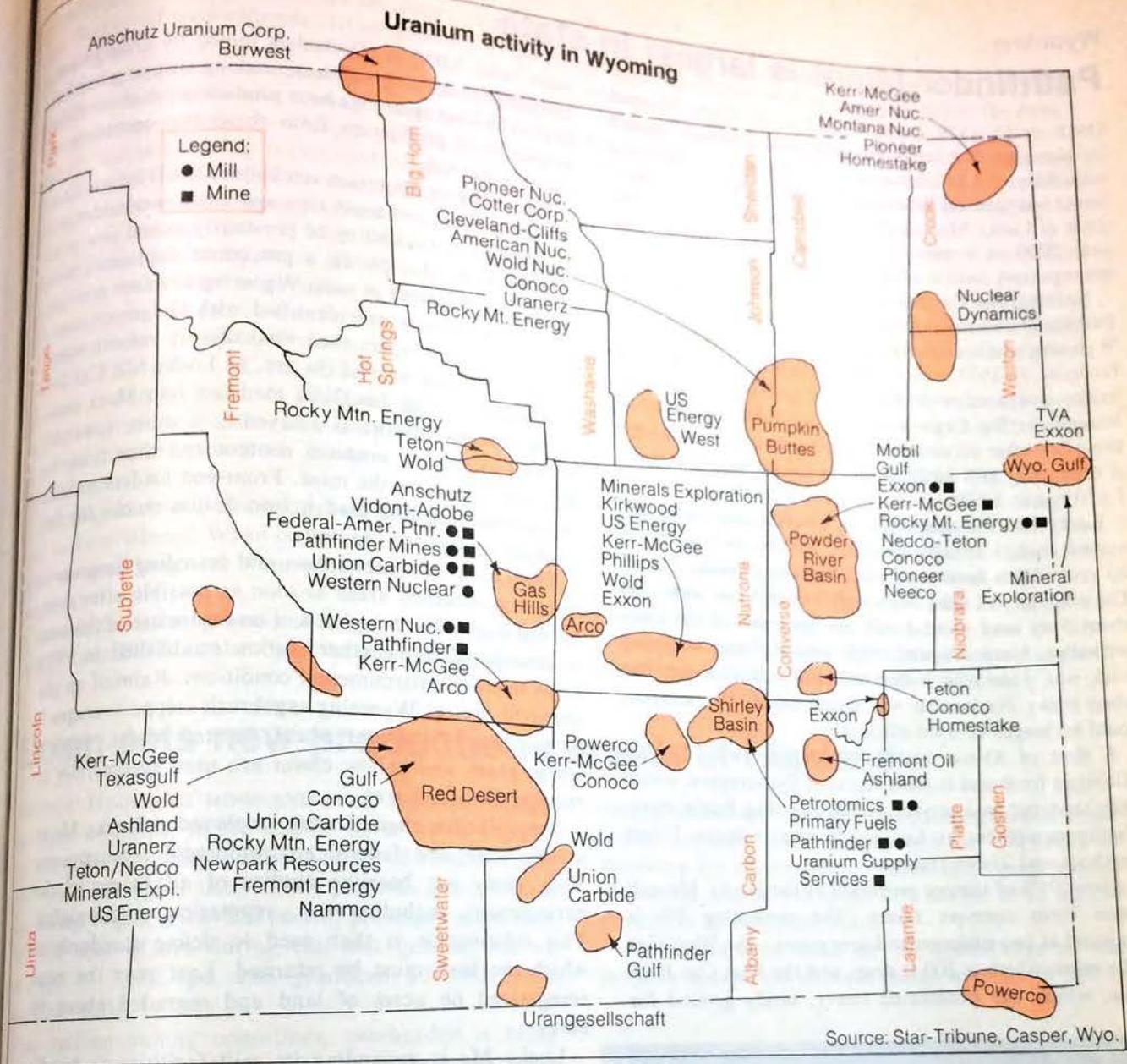
Uranium mills in Wyoming

Company	County	Ore capacity, tpd
Western Nuclear	Fremont	1,700
Pathfinder	Fremont	1,650
Union Carbide	Natrona	1,200
Federal American	Fremont	950
Exxon, USA	Converse	3,000
Rocky Mountain Energy	Converse	1,650
Pathfinder	Carbon	1,850
Petrotomics	Carbon	1,950
Total capacity, mid-1978		13,950
Mills to start up 1978-1980		
Minerals Exploration	Sweetwater	3,000
United Nuclear	Converse	2,000
Kerr-McGee Nuclear	Converse	1,200
Total additional capacity		6,200
Total scheduled by 1980		20,150
Potential mills after 1980		
Cleveland Cliffs	Campbell	1,000
Rocky Mountain Energy	Fremont	1,200
Union Carbide	Sweetwater	2,000

Activity flourishes in all districts

Wyoming's major uranium areas include the Gas Hills, Powder River Basin, Shirley Basin, Copper Mountain, Red Desert, Black Hills, Pumpkin Buttes, Crooks Gap-Green Mountain, and Kaycee. Although exploration and development drilling continues in all districts, the most active areas, in descending order, are Powder River, Gas Hills, Crooks Gap-Green Mountain, Red Desert, and the Black Hills.

The southern Powder River Basin is well on the way to becoming the state's leading uranium-producing district, winning out over the Gas Hills district, which has held top place since the uranium industry began in the state. More than 10 companies are active in the Powder River area, with three mines—operated by Rocky Mountain



Energy, Exxon, and Kerr-McGee—already producing. Of particular interest in Wyoming's uranium bonanza are the variety and number of companies involved in mining. Only a few years ago, companies in the uranium industry within the state were few, and all were well known. At last count, well over 40 companies were seriously involved in uranium—in planning, exploration, mining, milling, or putting together a consortium.

Wyoming's growing list of uranium producers

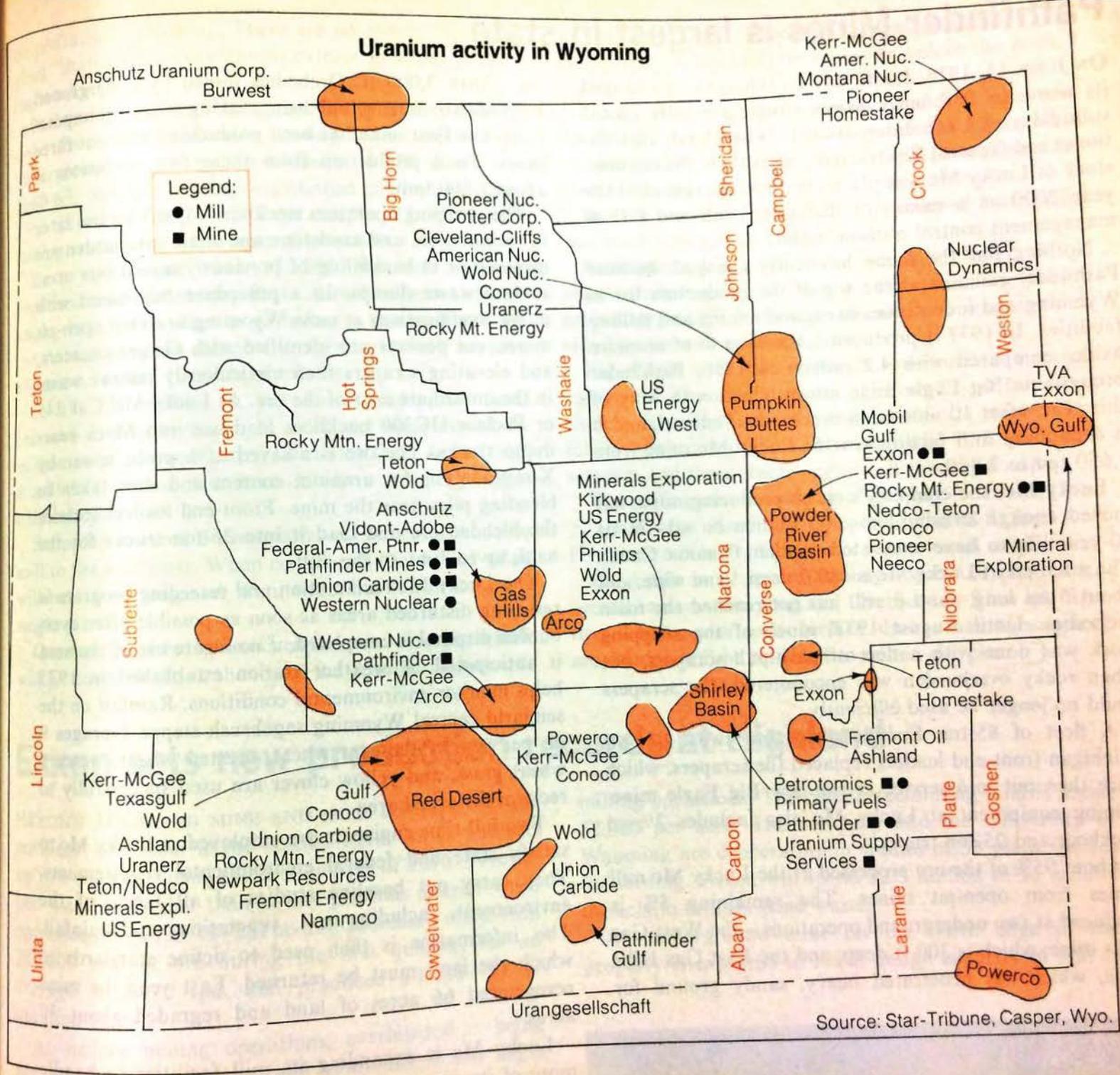
The eight companies that mine and mill uranium in Wyoming have a total milling capacity of 13,950 tpd. Three companies with mines and mills in the works are expected to add an additional 6,200 tpd of milling capacity by 1980, increasing the total to about 20,000 tpd. Three additional companies have announced plans to install mills with a combined milling capacity, after 1980, of 4,200 tpd.

Two companies mine uranium but do not operate mills. One company is scaling up a pilot solution mining method to commercial production, a project that should be completed by year's end.

Until recently, most of Wyoming's uranium production came from open-pit mines. But with ore being encountered at greater depths, underground mines are assuming a larger share of production. Exxon, Kerr-McGee, and United Nuclear are producing from underground mines in the Powder River Basin. Other companies have similar plans.

In-situ leaching is also taking hold in the state. Wyoming Mineral Corp., a subsidiary of Westinghouse, expects to have a 500,000-lb-per-year operation at full production by the end of next year. Other Wyoming producers also are active in this area. During 1977, in-situ plants produced about 700,000 lb of U_3O_8 in the US, primarily in Texas. Wyoming may add substantially to this figure in the next few years. □

Uranium activity in Wyoming



Source: Star-Tribune, Casper, Wyo.

Pathfinder Mines is largest in state

ON JUNE 15, 1978, Lucky Mc Uranium Corp. changed its name to Pathfinder Mines Corp., a wholly owned subsidiary of Utah International. When Utah International and General Electric merged in 1976, the common stock of Lucky Mc was placed in a voting trust until the year 2000 as a means of divesting Utah and GE of management control of these assets.

Nothing but the name has really changed, because Pathfinder remains at the top of the production list in Wyoming and it continues to expand mining and milling facilities. In 1977 it produced 5.1 million lb of uranium oxide, compared with 4.2 million in 1975. Pathfinder brought its Big Eagle mine into production in May of this year, after 10 months of overburden removal, and it is expanding mill facilities at the Lucky Mc mine from 1,650 tpd to 2,800.

Lucky Mc, the company's oldest producing mine, has moved enough overburden—300 million cu yd—in its 20-year life to have excavated another Panama Canal. The main pit at Lucky Mc is 480 ft deep, ½ mi wide, and about 5 mi long—and it still has not reached the main orebodies. Until August 1977, much of the stripping work was done with a fleet of push-pull scrapers, but when rocky overburden was encountered, the scrapers could no longer be used efficiently.

A fleet of 85-ton Euclid trucks and two 12-cu-yd Michigan front-end loaders replaced the scrapers, which were then put into service at the new Big Eagle mine. Mining equipment at Lucky Mc also includes 2½-yd backhoes and 25-ton trucks.

About 95% of the ore processed at the Lucky Mc mill comes from open-pit mines. The remaining 5% is produced at two underground operations—the West Gas Hills mine, which is 300 ft deep, and the East Gas Hills mine, which has penetrated heavy, sandy ground for



A 2½-yd backhoe loads out a 25-ton truck at the Shirley Basin mining operations of Pathfinder Mines Corp.

more than 3,000 ft. Orebodies mined by underground methods are narrow and deep, making stripping operations difficult. The East mine has been producing for about 10 years. Total production from these two operations is about 1,600 tpm.

The stripping operation stockpiles topsoil for use in reclamation, and sandstone and shale overburden is disposed of in backfilling of previously mined pits and surface waste dumps. In a procedure duplicated at most Wyoming uranium mines, ore pockets are identified with Geiger counters and elevating scrapers then meticulously remove ore in the immediate area of the ore. At Lucky Mc, Caterpillar or Poclair HC300 backhoes load ore into Mack dump trucks. The ore is assayed at a probe tower and X-ray analysis for uranium content and then taken to blending piles near the mine. Front-end loaders take the blended ore and load it into 35-ton trucks for haul, up to 7 mi, to the mill.

The Lucky Mc reclamation and reseeding program restores disturbed areas as soon as possible after overburden disposal is completed, if no future use of the area is anticipated. A weather station established in the area helps monitor environmental conditions. In the semiarid central Wyoming sagebrush steppe average rainfall is 10 in. per year. Pubescent wheat, crested wheat, wheat grass, and yellow clover are used successfully to reclaim disturbed area.

Two full-time engineers are employed at Lucky Mc to satisfy state and federal environmental requirements. They carry out baseline studies of all facets of the environment, including soil, vegetation, and rainfall. This information is then used to define standards for which the land must be returned. Last year the mill revegetated 66 acres of land and regraded about 100 acres.

Lucky Mc is expanding its mill facilities to handle more of its own ore plus ore from the Big Eagle mine. Modifications will be completed late this year. Mill additions include a new semiautogenous, one-step grinding facility. Other equipment has been added to increase leach agitation capacity and to expand CCD thickening and washing circuits.

Leaching at the Lucky Mc mill is followed by uranium extraction in a moving-bed resin circuit and solvent extraction upgrading in a solvent extraction circuit.

Lucky Mc's safety record is improving. In 1977, 10 lost-time accidents were reported. Only two were reported at midyear 1978.

At Pathfinder's Shirley Basin operations, the most recent change in mill equipment has been the installation of a new yellowcake dryer to improve efficiency. The last mill modification, which was made a few years ago, was the addition of a cyclone wash that washes slimes through five successive cyclones in series. Slimes throughput in the CCD circuit. This addition increased mill throughput from 1,200 tpd to 1,800.

Shirley Basin ore is milled in an autogenous mill, which

no preliminary crushing. There are no conveyors in the plant. Static-bed resin columns extract uranium following leaching.

Pathfinder has been mining the Shirley Basin property since 1960, with production coming from conventional underground operations, to a depth of 250 ft, during 1960-63. Solution mining maintained production from 1963 through 1970. The mill was completed in 1971, and mining was converted to open-pit methods.

Last year, more than 250,000 tons of ore was produced from the Shirley Basin Area 2 mine, which has about three more years to go before it is mined out. At the Area 3 mine, to the northeast, reserves will support at least a further 10 years of mining.

In all, 150 million cu yd of overburden has been removed at Shirley Basin. In 1977, the mine moved 24 million cu yd of overburden, 18 million from Area 2 and 6 million from the new Area 3, where stripping began only last year.

Stripping of Area 3 eventually will sweep around the mill to the southeast. When completed, the Area 3 mine will be 1½ mi long and ½ mi wide, but it will not be a single pit.

Overburden is being removed from an oval pit, which will go down 270 ft, to the top of the ore zone. Depth will

not exceed 300 ft. About six months of additional overburden removal will be necessary before the Area 3 mine is in ore.

Primary stripping equipment in Area 2 includes two P&H 2100 15-yd shovels loading into 14 LectraHaul 120-ton trucks. Fourteen 24-yd 657 Cat scrapers are used in waste removal.

In Area 3 mine, a 20-yd P&H 2300 shovel is stripping into seven new Euclid 170-ton trucks.

Pathfinder's Big Eagle mine, south of Jeffrey City, began producing ore in May of this year. The mine's main stripping pit is divided into nine subpits, of which only two are now producing ore.

Big Eagle uses two types of overburden removal equipment. One fleet consists of three 12-yd front-end loaders, four 75-ton trucks, and two 85-ton trucks. The other group consists of 12 twin-engine 657 push-pull scrapers and three single-engine self-loading scrapers.

The mining unit is made up of two backhoes and three 22-ton trucks. Auxiliary equipment includes four Cat D9s, four motor graders, and a rubber-tired dozer.

Big Eagle has been stockpiling topsoil as part of its overall reclamation program. Overburden from the first two subpits goes to a surface dump, but subsequent overburden will be returned to mined-out pits. □

Exxon sets new production records at Highland

EXXON'S HIGHLAND MINE AND MILL complex, 60 mi northeast of Casper in the Powder River Basin, chalked up new records during the first quarter of 1978. Production was 13% higher than in any previous quarter since operations began in 1972. The mill processed more than 287,000 tons of ore during the first quarter, for an average of 3,230 tpd, and produced 830,000 lb of uranium oxide.

At surface mining operations, overburden is being removed from the third pit and mining there will begin soon. Pit No. 1 was mined out in 1977.

Pits are designed to be stripped in 40-ft benches, maintaining a slope of 50° to 52°. Ramp grades are held to a maximum of 7%, and road width is at least 100 ft.

Waste is backfilled into mined-out pits when possible; otherwise, it is disposed of in dumps on the surface. Dump height is held to 25-35 ft. When completed, slopes are reduced to 3:1, covered with topsoil, and mulched, seeded, and fertilized. Exxon moves about 42,000 cu yd of overburden daily, or about 15 million cu yd annually.

Mining is carried out with five 2½- to 3½-cu-yd hydraulic backhoes. Normally, two units are assigned to mine ore and two to work in dewatering ditches. The fifth is held as a spare.

The ore fleet consists of three 50-ton and three 35-ton trucks. Elevating scrapers remove waste directly above and around the sides of the ore pockets.

Exxon has already reclaimed 550 acres—more than one-fourth of the land it has disturbed. In all, an estimated 3,000 acres will be disturbed by mining and

milling operations. The cost of reclaiming land is about \$2,000 per acre. The company and the University of Wyoming are cooperating in studies of 53 plant species for seeding. Exxon will spend \$2.5 million to \$3 million to reclaim tailings pond waste.

An underground mine on the north edge of the property is expected to reach design capacity of 800 to



Underground miners at Exxon's Highland operation install 'Split Set' friction bolts and wire mesh for rock support.



A grade-control technician samples ore near the ripper-equipped bulldozer (right) at Exxon's Highland open-pit mine. At left, a

2½-yd backhoe loads ore into 35- or 50-ton-capacity trucks. Each truck is subsequently sampled at a probe tower.

1,000 tpd by the end of 1978. The main shaft is 700 ft deep. The intake air shaft is located 3,000 ft away. (For a detailed description of the underground mine, see *E/MJ*, December 1977, p 61.)

Underground development is also proceeding from the bottom of the shaft of the company's new Buffalo mine. Designed capacity will be 1,000 tpd. The circular concrete-lined shaft, 14 ft in diameter and 715 ft deep, houses two skips in balance, hoisting from a single station. Haulage is on the 605-ft level. A Nordberg double-drum hoist handles the ore skips, and a Card hydraulic hoist handles the man-and-materials cage.

Production haulage is done by 6-ton locomotives and 110-ton Card side-dump cars.

At Exxon's Highland mine, in-situ leaching may reach the commercial stage within the next two years. By the end of 1978, the company hopes to have completed its application to expand the solution mining project. On the western rim of the property, the company is running pilot tests using an injection well and four observation

wells, 90 ft from the injection well. The observation wells prevent solution introduced into the injection well from escaping the 90-ft perimeter of the test area. Operating data are not yet sufficient for Exxon to proceed with full-scale solution mining.

The Highland mill processes 3,000 tpd, 50% more than the original design capacity. The increase was achieved primarily through modifications that include changing electric motor horsepower ratings, altering process lines, and refinements and additions to instrumentation. A minimum of new equipment was added.

Uranium extraction features a one-stage closed-circuit impact crusher, a single open-circuit rod mill, eight stages of acid leaching, five stages of countercurrent decantation washing, one-stage sand filter clarification, four stages of solvent extraction using tertiary amine and four stages of stripping using ammonium sulphate, two stages of precipitation and thickening, dewatering by centrifuge, calcining by six-hearth roasters, and packaging. □

Western Nuclear nears expansion goal

WESTERN NUCLEAR INC., a wholly owned subsidiary of Phelps Dodge Corp., is in the midst of a major expansion that will raise its yellowcake production capability in the Jeffrey City area from 600,000 lb per year to 2 million lb per year in 1979. The company's Split Rock mill, just north of Jeffrey City, has undergone a major modification and modernization program.

Mine development includes sinking of two shafts on Sheep Mountain, not far from Western Nuclear's Crook Gap mines. The mine expansion, including modernization of present operations, has been budgeted at \$14.8 million.

At present, 12,000 cu yd of overburden per day is

taken out of the McIntosh pit, and 22,000 cu yd per day is removed from the McIntosh South pit.

One-half of the mill's daily production comes from the open-pit mines and one-half from Western Nuclear's underground operations.

All mining of ore is done during the day shift. Ripping and ditching are done at night to remove interim waste so that mining can continue at full pace the next day.

Mining is done by a backhoe-truck combination. The backhoes are equipped with 2.75-cu-yd buckets. Ore is loaded into 15-cu-yd trucks.

A fleet of 65-ton ore trucks take the stockpiled ore from the mine site, 12 mi south of Jeffrey City, to the

mill, which is 2 mi north of the town.

Interim waste in the McIntosh pit is removed by six push-pull scrapers. This phase of the operation is contracted.

Pits are backfilled with overburden removed from subsequent pits. Topsoil is stockpiled for use in future reclamation. Waste piles will be sloped, covered with topsoil, and seeded with grasses.

Orebodies of Western Nuclear's underground mines are erratic and hard to follow. All are roll front deposits. Five underground mines are now in operation, with depths varying from 150 to 1,400 ft. Sheep Mountain No. 2 is still under construction.

Several methods are employed in mining and hauling ore in Western Nuclear's underground mines. Access to the shallower mines, for example, is gained through inclined tunnels. Ore is blasted from the wall and loaded by small front-end loaders, which drop the ore through grizzlies to a lower level, where it is stored to await transport by rail to the hoisting shaft. From there, the ore is hoisted to the surface by a double-drum skip hoist.

The deepest mine in operation is Sheep Mountain No. 1. Ore is skipped to the surface by a double-drum hoist with a 4-ton capacity.

Western Nuclear's expansion of yellowcake production at the Split Rock mill has been scheduled in stages—about 1.3 million lb in 1976, 1.5 million in 1977 and 1978, and 2 million lb in 1979 or 1980, a rate that is planned to continue for the following six years.

Western Nuclear shut the mill down in the second

quarter of 1974 for rebuilding, which is now completed. A 6 x 18-ft Hardinge autogenous mill replaced the previously used crushing and rod and ball milling units, and capacity was increased in the resin-in-pulp circuit. Mill capacity is 1,500 tpd. Wet storage capacity was added following the autogenous mill, totaling about 1,200 tons in two 25 x 50-ft tanks, with actual storage capacity depending on the thickness of the slurry. Ground ore is leached through 11 leach tanks. A circuit of Esperanza drag classifiers and Krebs cyclones desands the leached pulp, and because the resin-in-pulp circuit tolerates fines, clarification of the leach liquor is not necessary.

The resin-in-pulp circuit was modified by adding two exhaustion tanks to the eight that previously made up the circuit and by splitting the flow into two five-stage exhaustion circuits to save wear and tear on resin. Resin flows countercurrent to pulp through the exhaustion circuit, and rubber-lined Rotex screens were installed in the exhaustion-circuit separators as another means of reducing resin breakage. Air lifts replaced pumps for pulp transfer in both the exhaustion and elution circuits.

The resin-in-pulp elution circuit was expanded from 14 to 18 tanks and split into two nine-stage elutions. Resin solution separation between stages of this countercurrent circuit is performed by cone separators.

Solvent extraction through Denver mixer-settler units, ammonia precipitation, thickening, centrifuging in a Bird centrifuge, and roasting in a hearth roaster precede the packaging section. □

Rocky Mountain Energy is newest producer

ROCKY MOUNTAIN ENERGY CO. dedicated its 1,000-tpd Bear Creek uranium mine-mill complex north of Douglas, Wyo., on Sept. 22, 1977—16 months after the start of construction in May 1976. The operation is an outgrowth of a six-year, \$24 million joint exploration venture with Mono Power Co., a subsidiary of Southern California Edison Co. Rocky Mountain Energy Co. (RMEC), a subsidiary of Union Pacific Corp., is the operating partner in the joint venture.

Production at Bear Creek has since been increased to 1,400 tpd of ore, a rate that will be maintained until 1990. RMEC's total reserves at Bear Creek are estimated at 4 million tons.

The company announced recently that the Bear Creek mill will process 150,000 tons of uranium ore over a three-year period for US Energy Corp. of Riverton. The tolling arrangement, one of the first of its kind in the area, is slated to begin before yearend, when US Energy starts delivering uranium ore from properties near Kaycee.

US Energy is the operator of properties owned by St. Clair Energy Corp., a subsidiary of Detroit Edison Co., and Westan Kaycee Ltd. When uranium ore is delivered under the tolling agreement, US Energy and its affiliate, Ruby Mining Co., may each acquire a 10.5% interest in

the properties operated by US Energy.

(For a detailed description of the Bear Creek complex, see E/MJ, October 1977, p 76.)

RMEC's major thrust at the present time is exploration and development of uranium reserves elsewhere in Wyoming. Work on significant uranium reserves at Copper Mountain, for example, is being conducted as a joint venture by RMEC, Great Basin Petroleum Co., and Mono Power Co. A \$20 million program is underway to delineate further the extent of orebodies, to determine mining techniques, and to provide data for mine and mill design and for permit applications. If the program is successful, the project could be in production by 1982.

RMEC, the operator, has a 30.3% interest in the project, with Great Basin holding 30% and Mono Power the remaining 39.7%. The Copper Mountain property is 100 mi west of Casper in the Owl Creek Mountains. Recoverable reserves, estimated at 10 million lb of U_3O_8 , may be increased by drilling on two orebodies whose extent has not been defined.

RMEC also announced this year that it plans to spend \$12 million to develop uranium reserves on two properties in Wyoming using in-situ leaching methods of extraction.

Wyoming

Development work will be conducted at Nine Mile Lake, north of Casper, and at Reno Ranch, approximately 85 mi north of Douglas.

Other participants in the development program are Mono Power Co. and Halliburton Co. The partners have been investigating in-situ leaching technology since 1974 and have successfully demonstrated the commercial feasibility of the technique at the Nine Mile Lake facility since 1976. Following additional investment to establish wells and construct processing facilities, it is anticipated that production from the two sites will reach 500,000 lb of uranium oxide annually in 1981.

Producers and newcomers push development plans

WYOMING URANIUM ACTIVITY spans a wide range of companies in various stages of exploration, mine development, and mill planning. Exploration activity, reviewed in greater detail elsewhere in this issue, continues at a fast pace despite governmental red tape. Footage drilled in 1978 is expected to exceed 17 million ft, up from 15.4 million ft in 1977, when it accounted for 37.6% of the US total.

Large petroleum companies lead the drilling activity, followed by smaller petroleum and mining companies and independent operators. In general, drilling depths are increasing and ore grades are falling. However, significant exploration successes are still being recorded.

At the Hauber mine in northeastern Wyoming, Homestake Mining Co., in cooperation with a utility company, is completing the third year of a four-year exploration and development program. The mine, which produced 350 tpd from a 400-ft shaft in 1957, supplied ore to the Edgemont, S. Dak., mill, which is now shut down. TVA recently purchased the mill, but no plans for reactivation have been announced.

Petrotomics mines and mills again

Milling operations have resumed at the 1,500-tpd Petrotomics plant in the Shirley Basin, after a three-year layoff. In early 1975, Getty Oil and Skelly Oil acquired Kerr-McGee Nuclear Corp.'s one-half interest in Petrotomics Co. The mill, with a capacity of 1,500 tpd of uranium ore, had been closed since November 1974, following temporary termination of uranium mining conducted there by KGS-JV, a joint venture of Getty Oil, Skelly Oil, and Kerr-McGee.

Although the Petrotomics mill was idle during 1975, equipment was kept in operating condition, and refurbishing and process improvements were made in anticipation of resuming production in the area in 1977.

The mill is now processing ore from UJV, a joint venture of Getty and Skelly. UJV holds properties in the Shirley Basin estimated to contain 6.9 million tons of in-place reserves having an average grade of 0.19% uranium oxide, or 3.8 lb per ton. Sections 4 and 33 are estimated to contain 4.5 million tons of in-place ore

For the past several years, RMEC and Marconella Inc. have been engaged in a joint venture to research hydraulic mining of uranium-sandstone through a borehole. This technique employs a water jet to break and slurry the uranium ore so that it may be pumped to the surface. The test was performed in the Powder River Basin, with encouraging results.

(The Bear Creek operation of Rocky Mountain Energy was described in a paper, "Assessment of New Technology at Bear Creek Uranium Co.," presented at the AMC meeting in Las Vegas in October 1978 by E. A. Lang, a vice president of the company.) □

reserves of 0.23% uranium oxide. Construction of a facility for mine equipment maintenance began in late 1975, along with removal of overburden.

At present, the Petrotomics mill is also processing ores from the Jenkins project of Utility Fuels Inc., a few miles away.

Getty reached ore in January 1978 in the Sect. 4-33 mine. Ore processing began in June. At the rehabilitated mill, a new yellowcake dryer and an improved dust collection system have been installed.

More than 40 million tons of overburden have been removed from the 4-33 mine. Over the estimated 10-year life of the mine, more than 200 million tons of overburden will be excavated. Stripping is done by two P&H 2300 shovels with 27-cu-yd buckets loading into Unit Rig M120 Lectra Haul trucks.

Mining is done with Cat 2½-cu-yd backhoes loading into 35-ton Euclid trucks. Mine waste is removed by three Marathon LeTourneau Model 1700 front-end loaders with 13-cu-yd buckets, an M-LT Model L800 with a 15-cu-yd bucket, and a Hough Model 580 front-end loader with a massive 25-yd bucket. The M120 trucks haul mine waste. Petrotomics will be experimenting in overburden loading and removal with a Unit Rig "Unimatic" bucket wheel loader, which has been beefed up for the job.

Union Carbide adds heap leaching

Union Carbide's Gas Hills operations have responded to stronger uranium demand by stepping up mine production and mill throughput and by installing heap leaching operations. The company's Gas Hills uranium mill has set production records for the last two years.

Capacity of the Gas Hills mill has been expanded to 500,000 tpy of feed. Mill throughput has been increased by speeding up the mill, increasing the sizing on the cyclones, and adding ion exchange capacity. The company expects to produce 1 million lb of uranium oxide this year.

Union Carbide is constructing a large heap leach project that will be 1,200 ft long, 600 ft wide, and 22 ft high.

Major equipment at Union Carbide's open-pit mine

includes push-loaded scrapers, self-loading scrapers, a 6½-cu-yd front-end loader, and 35-ton rear-dump trucks. The company also is experimenting with Caterpillar's new D10 dozer. A beta-gamma scanner provides grade control at the pit.

Mill equipment includes a jaw crusher and an open-circuit rod mill that grinds to minus 28 mesh. Eight leach tanks in series comprise the leach circuit, followed by countercurrent decantation washing cyclones and classifiers. Slimes report to a thickener and sand to tails. An ammonia pH adjustment is made on thickener underflow. Eight countercurrent resin-in-pulp stages extract uranium. Resin strip takes place through 11 cells, followed by a four-stage ammonia strip. Yellowcake is precipitated with ammonia.

Federal-American expands in all directions

A major expansion of the Federal-American Partners uranium mill in Wyoming will triple the current 1,000-tpd capacity at a cost of about \$34 million. In addition, the partners are gearing up for a major mining operation, in cooperation with the Tennessee Valley Authority, to supply uranium concentrate for TVA nuclear power plants.

In both Wyoming and Canada, all Federal-American production is committed under long-term contracts that specify a floating price to reflect anticipated increases in world uranium prices.

Stripping capacity has been increased by 450,000 cu yd per month with a new Marion 191M shovel equipped with a 15-cu-yd bucket, and several new pits have been opened up. The company's scraper fleet stripped the overburden from the Clyde-Bret pit, and mining has begun there. It then moved on to the Sagebrush-Tablestakes site and from there it went to the Sunset property. Stripping is now in progress on the East Gas Hills Cap property.

In addition, an underground mine is being developed to produce ore at the 1,050 level. The main shaft is expected to be completed in late 1978 or early 1979.

A new mine for American Nuclear

American Nuclear Corp., in conjunction with the Tennessee Valley Authority, plans to begin construction of the Cotter Ferguson mine in late 1978. Work will begin upon receipt of the mine permit from the state Department of Environmental Quality. The mine will be located south of the Lucky Mc mine of Pathfinder Mines Corp. The Federal-American Partners mine, in which American Nuclear is a 40% partner, also is nearby.

The Cotter Ferguson mine will be on the Peach claim group, in an established mining district, and mining and reclamation methods will be similar to those being used by other companies in the area.

The project will require a capital investment of \$60 million to tap known reserves of 7 million lb of U₃O₈. Stripping will be carried out by a truck-shovel combination, with two 19-cu-yd electric shovels loading into a

fleet of 170-ton rear-dump trucks.

The mine will have seven individual pits, or pushbacks, with waste from each pit placed in the preceding one. Reclamation will proceed as mining progresses, with all of the pits to be refilled and revegetated except possibly the last two pushbacks, which may be developed into recreational lakes.

Capital investment and mine operating costs will exceed \$300 million during the 10-year life of the mine. At peak production, the mine will move 22 million cu yd of material annually, and mine production will be 375,000 tpy. About 1 million lb of uranium oxide will be produced annually.

American Nuclear continues to work with TVA on five exploration projects and has identified a total of 32 million lb of uranium oxide, in which American Nuclear's net interest is about 14 million lb. Additional reserves are being proven in this year's drilling program. American Nuclear and TVA's exploration budget for 1978 is \$5.6 million, up from last year's budget of \$3.4 million.

In addition to general exploration on the properties, a considerable amount of close-spaced development drilling is being done to pinpoint reserves found in earlier exploration.

TVA and American Nuclear have invested about \$2.8 million to drill out the Peach property. An additional \$1 million is budgeted for feasibility studies and preproduction planning for the Cotter Ferguson mine. The two firms also have done extensive exploration on top of Beaver Rim and south through the Sweetwater claims.

American is attempting to identify the deep hidden valleys in the Sweetwater area by using seismic techniques. So far, drilling indicates good correlation with the seismic results as deep as 1,100 ft.

Startup at Morton Ranch scheduled for 1980

United Nuclear Corp.'s Morton Ranch mine may be in full production by early 1980, as construction could begin as early as the last quarter of 1978. The mill will take about 15 months to complete. Estimated cost of the mill alone is slightly less than \$35 million.

The mine will be located on the Morton Ranch, which is about 18 mi north of Douglas and encompasses about 26,000 acres.

United Nuclear is working on the tailings disposal plan, environmental reports, and radiological assessments. A series of three settling ponds has already been constructed. UNC has been mining some uranium from the first pit for metallurgical testing, and on the northern portion of the property, Teton Drilling Co., a subsidiary of UNC, is doing development drilling to block out orebodies.

In addition to the open-pit mine, United Nuclear is developing an underground mine on the northern edge of the property. The main shaft is 740 ft deep. Track and development work is at the 630-ft level. Drifting is expected to extend about 3,000 ft from the main shaft. The underground mine also is slated to be in full

Wyoming

production by 1980.

United Nuclear and the Tennessee Valley Authority estimate that the properties contain 11.4 million lb of uranium oxide. As half owner, TVA would get 5.7 million lb, or 5% of its identified needs through 1990.

Kerr-McGee mines Bill Smith underground

A new underground mine in the Powder River Basin has returned Kerr-McGee to the ranks of Wyoming uranium producers. The company's Shirley Basin mines were shut down in 1974 after being mined out.

Kerr-McGee's drilling program has included exploration in the Red Desert and Green Mountain districts, which has outlined potentially mineable reserves, and drilling in the Powder River Basin.

The production shaft for the new Bill Smith mine was bottomed out in November 1974, and the main shaft station has been equipped at the 870 level.

The mine will be worked by modified room-and-pillar techniques. The haulage level of the mine is equipped with 36-in.-gauge track. Haulage is carried out by an 8-ton Plymouth locomotive and 110-cu-ft cars.

The 14-ft-dia, concrete-lined shaft is equipped with a Nordberg double-drum hoist and two 110-cu-ft skips in balance.

Kerr-McGee's future uranium development plans, which include several open pit and underground mines, have run into trouble with state agencies. A final decision to settle the disputes should be made in the near future.

Mullen Mining well into four-year project

Mullen Mining Co., operating in the Shirley Basin, relies entirely on large crawler-tractors and a fleet of tractor-scrappers to perform stripping at the four-year Jenkins project. Some 21 million cu yd of overburden will be excavated, at the rate of more than 36,000 cu yd per day.

The scraper hauls tend to be long—3,000 ft to 5,000 ft

one way—and the mining company keeps haul road surfaces well maintained. The dumps are in previously mined areas of the pit, which makes backhaul routes relatively flat.

Overburden bench areas are often large, with ripping and push-loading done on a slight downhill grade. To speed push-loading by its fleet of 12 Cat 651 and 660 scrapers, Mullen chose a pair of 425-fwhp Fiat-Allis D9 tractors. Their speed and power make it advisable to team each one with two lighter Cat D9s to maintain push-load balance in the pit.

In the heavy, wet, consolidated sand and clay in the upper levels of the pit, the scrapers can take on a 45-cu-yd load in 25 sec. Rather than chain-load, with succeeding scrapers making one long cut down the bench, they work the width of the cut in succeeding passes. This system gives a smoother pit surface, permits faster spotting of incoming scrapers, and reduces nonproductive tractor time during a long return trip back to the beginning of the cut.

With production ranging from 35,000 to 50,000 cu yd per day on two shifts, equipment availability must be high.

The Jenkins project being stripped by Mullen is managed by Uranium Supply Services Corp. for Utility Fuels Inc., a subsidiary of Houston Industries Inc.

Wyoming Mineral: Solution mine at Irigaray

Wyoming Mineral Corp., wholly owned subsidiary of Westinghouse, plans commercial development of its Irigaray uranium solution mine in southeastern Johnson County.

The mining method consists of injecting liquid into an underground uranium formation, dissolving the uranium, and then pumping it to the surface. The company, which has been mining uranium solution at the rate of 100 gpm at the site, plans to increase the rate to 1,000 to 1,600 gpm. Planned capacity of the leaching process is 500,000 lb of uranium oxide annually—equal to the yield from mining about 750,000 tons of average-grade ore. □

State makes it tough to get okays for new projects

STATE AGENCIES AND ENVIRONMENTALISTS are raising a red flag to halt major uranium expansion in Wyoming. The Wyoming Industrial Siting Council, for example, has rejected a proposed compromise and ordered Kerr-McGee Nuclear Corp. instead to file for a permit for a proposed \$600 million uranium complex in Converse County.

Minerals Exploration, a subsidiary of Union Oil Co. of California, is under pressure from the Wyoming Environmental Quality Council, which charges that the company has made significant changes in plans since its application for a permit to construct a uranium mine and a 3,000-tpd mill in the Red Desert of southwestern Wyoming. As a result, the council has authorized its

staff agency either to dismiss the company's application or to accept amendments incorporating the changes.

The Wyoming Outdoor Council, an environmentalist group, has also made its objections known to Minerals Exploration and to the state. Minerals Exploration had hoped to be in production by September 1977. But its permit application was denied twice by the Wyoming Environmental Quality Council. When the permit was finally granted after the plan had been resubmitted, the Wyoming Outdoor Council charged that the state agency had overlooked important issues, such as possible lowering of the water table and improper design for the uranium tailings disposal.

A host of other companies are waiting to see how the

production by 1980. United Nuclear and the Tennessee Valley Authority estimate that the properties contain 11.4 million lb of uranium oxide. As half owner, TVA would get 5.7 million lb, or 5% of its identified needs through 1990.

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Kerr-McGee and Minerals Exploration cases are resolved. The outcome will determine other companies' approach to production and milling. Whatever the fate of the Kerr-McGee and Minerals Exploration projects, the cumulative effect of mines planned for the Red Desert appears certain to draw more environmental challenges. Ten to 12 projects are proposed for the area within the next three years by such companies as Union Carbide, Western Nuclear, Pathfinder, Conoco, and Texasgulf.

Before the latest setback, Minerals Exploration had begun mine and mill development at its Sweetwater uranium project, northwest of Rawlins. The company also had begun construction of a new 90-unit housing development in Rawlins for the mine and mill work force. Plans called for about 1 million lb per year of U_3O_8 production—from a 3,000-tpd mine and mill. In the planning and development stage for 2½ years, Minerals Exploration has already invested more than \$26 million in the project.

Although the Wyoming Industrial Siting Council now requires Kerr-McGee to submit a permit application within a year, the council is allowing development of one surface mine in the meantime, provided the number of persons employed does not exceed 150 at any one time. The council also exempted the company's Bill Smith underground mine from provisions of its ruling. Development of the full complex will require public hearings and preparation of a socioeconomic study, and also may require deposit of advance funds by the company to mitigate adverse environmental impacts on the community.

Before the council's decision, a proposed compromise would have allowed Kerr-McGee, without permit, to develop four surface mines in addition to the Bill Smith mine, which currently produces 700 tpd of ore.

The company's overall plan calls for development of

nine underground and four surface mines and a 2,500-tpd mill. Only one surface mine and two underground mines would operate at any given time, and a new trio of mines would be phased in as the others played out.

Among other companies with prospects in Wyoming, Cleveland-Cliffs Iron Co. is pushing ahead with plans to develop its uranium properties in the Pumpkin Buttes area, about 30 mi northeast of Edgerton and Midwest. Cleveland-Cliffs reportedly plans to open 20 uranium mines in the area in the next 20 years, employing 500 to 700 people.

Plans to develop the property—a joint venture of Cleveland-Cliffs, Getty Oil Co., Skelly Oil Co., and Nuclear Resources Inc. (a wholly owned subsidiary of Commonwealth Edison Co.)—were announced in late 1976. Full-scale mining and milling could begin in 1982, according to the companies.

Cleveland-Cliffs' exploration for uranium in Wyoming began in 1967. Four million ft of drilling has been done since the start of the operation—most of it on a 150,000-acre tract in the Powder River Basin.

A low-capital-cost system for mining and milling low-grade uranium deposits is scheduled for commercial testing early in 1979 in the Gas Hills district. Mullen Engineering, of Casper, Wyo., filed a permit application in July. The system was developed by Mullen for Adobe Oil & Gas of Midland, Tex., which has been exploring claims in the state owned by Vipont Mining of Englewood, Colo.

In the Pumpkin Butte area of Wyoming, near Edgerton, Continental Oil is conducting environmental studies for a mine site that would cover 1,280 acres.

Urangesellschaft USA, subsidiary of a West German company, is preparing to open a 3,000-tpd mine and mill in the Poison Basin, near Baggs, where uranium was formerly mined. The operation is expected to cover 3,000 to 6,000 acres. □

NURE evaluates promising quadrangles

THE STATE OF WYOMING is receiving its share of help from the National Uranium Resource Evaluation program (NURE) in efforts to locate and evaluate uranium deposits. Geologists of Bendix Field Engineering Corp.'s field office at Casper, Wyo., are evaluating areas encompassing the states of Wyoming and North Dakota and parts of South Dakota, Montana, Nebraska, Minnesota, Wisconsin, and Michigan.

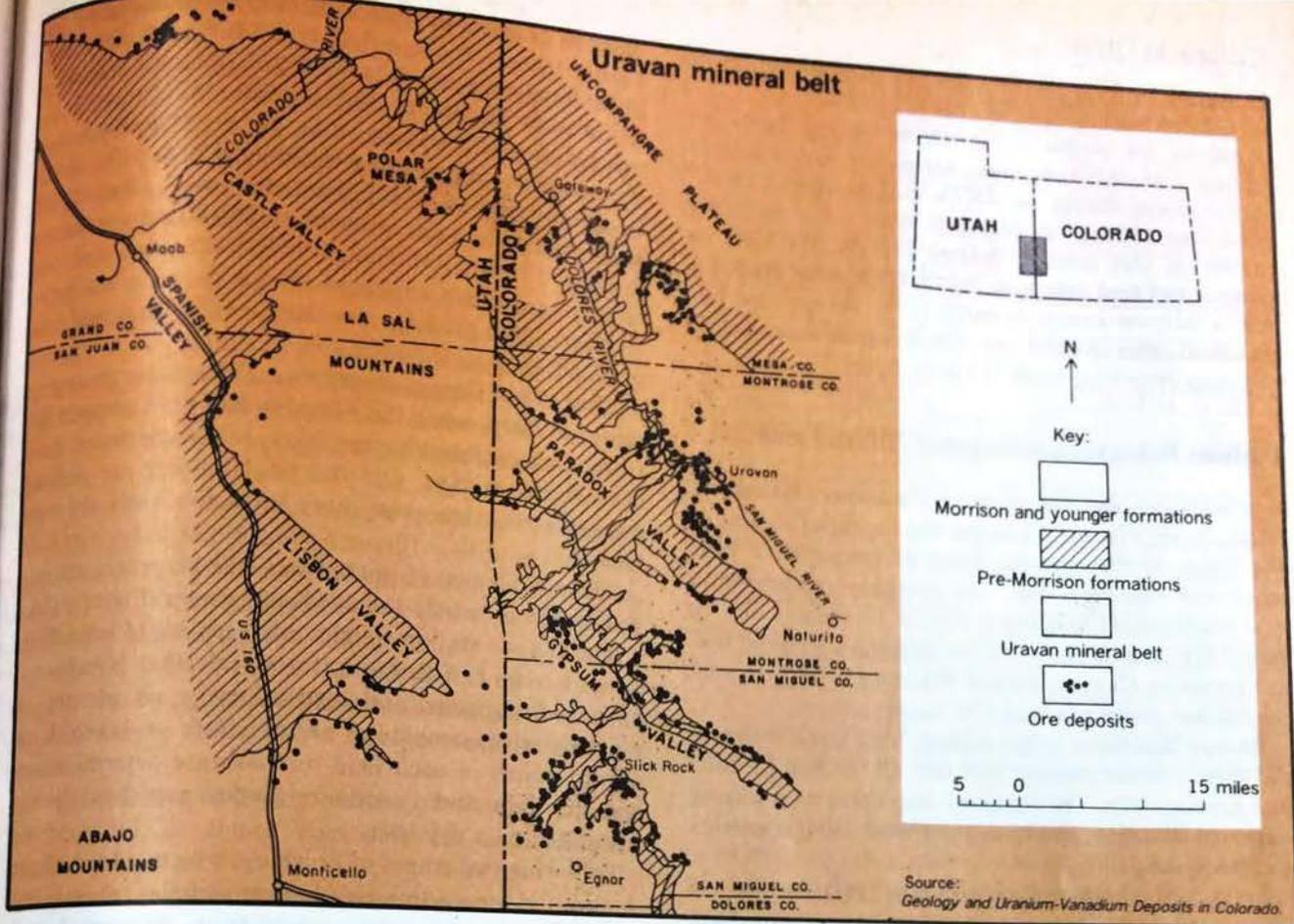
The primary task of this regional office in the latter part of 1977 was the evaluation of specified quadrangles to determine areas favorable for the occurrence of uranium. Surface and subsurface investigations, follow-up investigations of aerial radiometric surveys, and hydro-geochemical and stream-sediment sampling programs are being used in these studies. Work on the quadrangle evaluation was started last year, and a number of preliminary studies and projects have been completed.

Projects underway within Wyoming that are scheduled for completion by 1979 include:

- Cheyenne quadrangle. The geologic environments being evaluated in this study are Tertiary and Cretaceous sediments of the Denver and Laramie basins, and the Precambrian igneous and metamorphic rocks of the Laramie range.

- Casper quadrangle—including the Granite Mountains, Shirley Basin, the northern portion of the Laramie range, and parts of the Wind River Basin, Powder River Basin, and Great Divide Basin. Rocks in the area range in age from Precambrian to recent. Three major uranium districts—Crooks Gap, Shirley Basin, and Gas Hills—produce from Tertiary sandstones.

- Rawlins quadrangle. This study area includes a variety of geologic environments, from the fluvial sandstones of Tertiary basins to the Precambrian rocks of the adjacent Medicine Bow and Sierra Madre Ranges. Some of these Precambrian rocks are approximately equivalent in age and lithology to uranium-bearing conglomerates of the southern Canadian Shield in Ontario. □



Wide-ranging activity marks uranium boom in Colorado and Utah

Lane White, Managing editor

THE MOST VISIBLE URANIUM PRODUCERS in Colorado and Utah are the mill operators—Union Carbide, Atlas Minerals, Cotter Corp., and Rio Algom—but the scattered, usually small uranium deposits in these states make them one of the last strongholds of the small mine operator. By one estimate, 150 mines are being worked to a greater or lesser degree in western Colorado and eastern Utah, with about two-thirds of them on the Colorado side of the state line. Exploration drilling is up sharply, with utility companies financing much of the action, and three relatively new companies—Plateau Resources, Energy Fuels, and Pioneer Uravan—have announced their intention to build mills.

Pioneer Uravan plans a 1,000-tpd mill to be built near Slick Rock, Colo., in a joint venture with a utility company. Kaiser Engineers has the engineering design contract, Dames & Moore will conduct geotechnical studies and design a tailings pond, and Kilborn/NUS is preparing an environmental study.

A less conventional source of U_3O_8 will be tapped by Brush Wellman, which has announced plans to recover

byproduct uranium from beryllium ore at its Delta, Utah, mill. The \$1 million plant will have a capacity of 20,000 to 40,000 lb per year of U_3O_8 .

Energy Fuels plans mill at Blanding

An aggressive newcomer to the uranium business, Energy Fuels Nuclear Inc. is planning to build a 2,000-tpd mill at Blanding, Utah. The company, headed by Bob Adams, former president of Western Nuclear, will have a 60% interest in the plant, with two Swiss utilities holding the remainder. Western Knapp has the engineering and construction contracts for the mill, which will include a vanadium circuit.

Energy is currently operating ore buying stations at Blanding and Hanksville, Utah, where uranium ore from as many as 150 mines is purchased at prices based on the Nuexco exchange value for yellowcake. Many of the mines are owned by Energy but subleased to independents, who operate the mines on their own account. The company also plans to develop and mine several acquired

Colorado-Utah

properties, with the goal of producing as much as 70% of its mill feed from properties that it controls.

Among the properties in which Energy holds an interest is the Mi Vida mine, formerly Charles Steen's star producer during the 1950s uranium boom (E/MJ, September 1953, p 73). Minerals West is the operating partner in this venture. Adams expects Mi Vida to produce mill feed averaging 0.13% U_3O_8 when reactivation is fully on stream in early 1979. Energy also has numerous other mineral interests in southeastern Utah, including properties south of Green River.

Plateau Resources schedules 750-tpd mill

A wholly owned subsidiary of Consumers Power Co. of Michigan, Plateau Resources has expanded rapidly in the Colorado Plateau area since its formation a little more than two years ago. The company moved into a new headquarters building in Grand Junction, Colo., in May 1978, and its plans call for building a 750-tpd mill at Shooting Canyon, west of Blanding, Utah. Its total payroll has grown to about 150 employees.

Plateau Resources is developing three small mines in the vicinity of the planned mill site, all reached by adits into canyon walls. The company also operates a buying station at Blanding, purchasing ore from small operators and stockpiling it.

In an active exploration program, Plateau had as many as 14 drills working in 1977, but the number has dropped to about eight in 1978. The company's geologists have taken a look at most of the areas of active uranium exploration in the western US.

If permitting procedures stay on schedule, Plateau could begin construction of a mill in the Shooting Canyon early in 1979. The Nuclear Regulatory Commission is the governing body. Mountain States Engineers has the contract for design and construction of the mill, and production could begin 14 months after start of construction.

GE buys ore in a competitive market

Establishment of a uranium ore buying station at Naturita in 1975 by General Electric Uranium Management Corp. (Gemco) sparked a surge of activity among small mine operators in the Uravan district. The Gemco buying contracts provided for payments to be based on prevailing spot prices for U_3O_8 , while established buyers such as Union Carbide and Atlas Minerals could not match such terms because their U_3O_8 production was committed to long-term contracts at prices substantially below the spot market.

Gemco is now taking deliveries of 5,500 to 6,000 tpm of uranium-vanadium ores at Naturita, with ore arriving from about 15 shippers per month. The company has signed about 65 ore buying agreements, and since its operations began in 1975, it has taken deliveries from 35 sellers.

plied by a recovery factor of 0.95, plus one-third the average range of E/MJ prices for 98% fused V_2O_5 multiplied by a recovery factor of 0.80, plus or minus an adjustment factor for U_3O_8 grade. Adjustments are upward for ore grading more than 0.20% U_3O_8 and downward for ore grading less than 0.20% U_3O_8 . Adjustments range up to \$24 per ton for ore grading 0.35% U_3O_8 , and deductions range up to \$16.00 per ton for ore grading 0.10% U_3O_8 . Gemco is not obligated under its buying agreements to accept—nor is the seller obligated to offer—ores grading less than 0.10% U_3O_8 nor ores grading less than 0.50% V_2O_5 .

Most of the Gemco contracts are five-year agreements signed in 1975, when the company had little competition from other potential buyers. Now, other purchasers have entered the market, and the small miners are seeking contracts that are even more attractive than those of Gemco.

The ore Gemco is purchasing will be processed into yellowcake to satisfy the needs of General Electric Co.

The Gemco station weighs in all truckload lots of ore on an 8 x 60-ft Toledo platform scale that is balanced daily and inspected and certified every six months. A representative sample of about 10 lb is taken from several points in each load for moisture determination, and uranium and vanadium grades are subsequently calculated on a dry basis.

Following two stages of crushing, which reduce all ore to minus 1½ in., a link-belt bucket sampler takes a 10% sample that is reduced to minus ¾ in. That product is subjected to a 10% or 20% cut, which is then reduced to minus ⅜ in. Another 10% cut is taken, blended, and split to about 30 lb for drying.

This fraction is reduced to minus 20 mesh, blended, split three ways, reduced to minus 100 mesh, and blended again. The final sample is split twice, and four sample pulps are made from the last split.

For uranium assay, a sample is given a mixed acid digestion, which is diluted, and interfering metal ions are removed by precipitation with cupferron and filtration at reduced temperatures in an acid solution. Residual organics are destroyed by heating with perchloric acid. Selenium, tellurium, and arsenic are distilled off as volatile bromides by mixed halogen acids. The diluted sample is then run through a Jones Reductor containing amalgamated zinc to reduce the uranium to a +4 valence. Any +3 valence uranium is air-oxidized, and the uranium is titrated with standard permanganate solution using ferroindol as an indicator.

To assay for vanadium, a sample is digested in a mixed acid, diluted, and reduced with ferrous ammonium sulphate. The vanadium is preferentially oxidized with potassium permanganate, and the excess $KMnO_4$ is reduced with sodium nitrite. The vanadium is titrated with standard ferrous ammonium sulphate, using sodium diphenylamine sulphonate as the indicator.

...sion program at its Moab, Utah, uranium-vanadium mill. Atlas Minerals has, over the past several years, lifted throughput above 1,200 tpd. The company plans eventually to raise capacity to 1,500 tpd. Expansion has tested the ingenuity of Atlas engineers, who have maintained production while replacing older equipment and installing new thickeners, filters, pumps, and pipes to eliminate bottlenecks that would impede increased ore flow.

Perhaps the most significant addition has been a new four-thickener CCD washing section that has raised capacity in the plant's acid leaching section to 700 tpd from about 450 tpd. Three 65-ft thickeners and one 90-ft unit comprise the new installation. Atlas is now adding another new 65-ft first-stage leach thickener and a 45-ft clarifier.

Six new Eimco drum filters have increased capacity in the Atlas mill's acid filtration circuit, and nine Peterson drum filters equipped with string discharge have been installed in the alkaline leach circuit to facilitate handling of sticky ores.

A central control panel and additional instrumentation are also being installed in the alkaline leach section, and new caustic and chlorate storage tanks are already in place.

In the yellowcake drying section, the hearth furnace has been rebuilt and a dust collector and scrubber replaced.

A resin-in-pulp circuit that has not been used in recent years will be dismantled to make room for additional new equipment.

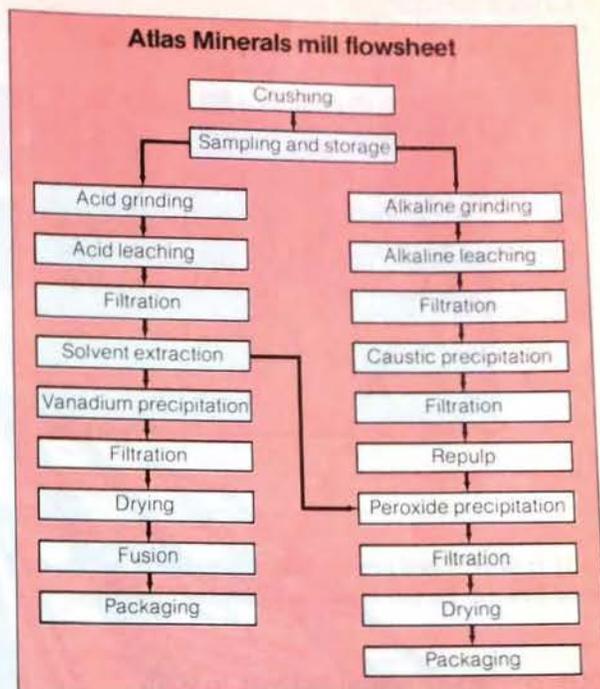
(For a more complete description of the Atlas mill operation, see *E/MJ*, January 1976, p87.)

Atlas draws most of its mill feed from its own mines; 13 operations were supplying 70-80% of the total early in October. Most of the ore is trucked to the Atlas mill from Lisbon Valley, 35 mi to the south, or from the Green River area, 55 mi north.

Ranchers reworks Naturita mill tailings

Ranchers Exploration and Development Corp. started up its Durita uranium tailings treatment project at Naturita, Colo., in December 1977, and as of March 31, 1978, the plant had produced 90,389 lb of U_3O_8 and 478,714 lb of V_2O_5 . The Naturita operation will have a 16-month life, treating 630,000 tons of tailings, after which the plant will be dismantled and moved to Durango, Colo., where it will treat an additional 1.46 million tons of tailings. Orloff Minerals Services Corp. has the engineering, procurement, and construction contract for designing, dismantling, moving, and reconstructing the plant.

The two tailings dumps are thought to contain about 2 million lb of U_3O_8 , and after early testing of the leaching circuit, Ranchers estimated that 65% of that total could be recovered. Since startup at Naturita, Ranchers has been close-mouthed about the performance of the plant. *E/MJ* was not allowed to see the operation during a visit to the Uravan mineral belt in July 1978.



The Naturita processing facilities include three clay-lined leaching tanks, each measuring 400 x 1,000 x 20 ft, 25 acres of clay-lined evaporation ponds, four plastic-lined solution collection ponds, and a water storage reservoir. The tailings are dried, crushed, and agglomerated in a 33-ft-long, 12-ft-dia, rubber-lined rotating cylinder, where the sand-like particles are also sprayed with sulphuric acid to ensure that they are thoroughly exposed to the leaching fluid. Prills formed during agglomeration are trickle-leached with sulphuric acid. The leach liquor then advances to a conventional solvent extraction circuit.

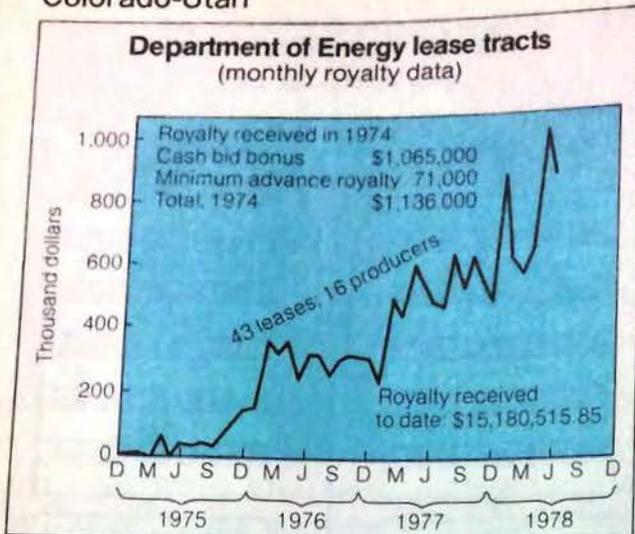
Tank trucks transport the U_3O_8 in slurry form to Kerr-McGee's conversion plant at Sequoyah, Okla. The uranium production is committed to Virginia Electric Power Co. Vanadium is shipped in solution to Union Carbide's plant at Rifle, Colo.

Ranchers also operates the Small Fry mine in the Big Indian district, 30 mi southeast of Moab, Utah. As of April 1978, the joint venture operation, in which Chaco Energy is a participant, had stockpiled 145,000 tons of ore, and a milling arrangement was being sought. Recent mine production has been described by the company as satisfactory in terms of tonnage, but grades have been disappointing. Ranchers' share of production during the first three quarters of fiscal 1977 (ended March 31, 1978) was 22,776 tons of ore containing 50,504 lb of U_3O_8 .

The Small Fry was mined during the early 1950s, but low grades—0.10% to 0.12% U_3O_8 —resulted in shut-down after only 68,000 tons of ore had been produced. Ranchers' reserves surround the old workings.

Access to the Small Fry is gained through a 600-ft-long decline, and production, by a contractor, comes from deposits in the Mossback formation that average 6

Colorado-Utah



to 10 ft thick. Good ore continuity, absence of water, and good haulage permit highly mechanized operations.

DOE centers uranium activity in GJO

The Department of Energy's Grand Junction office (GJO) makes its presence felt in Colorado Plateau uranium activity through its administration of Federal land leasing for mine development—and throughout the US as contract administrator for the National Uranium Resource Evaluation program (NURE). The department's lease tracts have turned into a moneymaker, producing more than \$1 million in royalties during the month of May 1978.

In a program that began in 1974, 25,000 acres in 43 tracts have been leased—38 in the Uravan mineral belt of Colorado, four in Utah, and one in New Mexico. The tracts range in size from 20 acres to 2,500 acres. The leases are valid for a 10-year period and can be extended for another 10 years at the option of the lessee.

When the program began, ore reserves on the tracts were estimated at 900,000 tons containing 3,000 tons of U_3O_8 and 20,000 tons of V_2O_5 . Most of the tracts are regarded as having good potential for further ore discov-

In coming issues of E/MJ:

What's happening in U_3O_8 finding and extractive technology

The magnificent Australian deposits

Action elsewhere in uranium

eries, and substantial reserves have been developed since 1974.

Eugene W. Grutt Jr., who recently retired as manager of the GJO, outlined its activities and organization at a Uranium Resource and Technology meeting held at a Colorado School of Mines in March 1978. The GJO staff totals 92 employees, 14 of whom are stationed at eight field locations, Grutt said. Major organizational units are the Resource Div., the Supply Analysis Div., and the NURE Project Office.

The Resource Div. prepares estimates of ore reserves and potential resources and maintains field contact with companies active in exploration and mining. In addition to its Grand Junction staff members, the Resource Div. is served by geologists stationed at Casper, Wyo.; Albuquerque, N. Mex.; Austin, Tex.; Reno, Nev.; Spokane, Wash.; Anchorage, Alaska; Atlanta, Ga.; and Pittsburgh, Pa.

The Supply Analysis Div. compiles industry production information, prepares forecasts of uranium production capability, and studies the economics of uranium supply.

The NURE Project Office manages an extensive resource evaluation program, currently the major activity of the Grand Junction office. Its staff works with the various groups of Bendix Field Engineering Corp. (the NURE "on-site" contractor), and with DOE laboratories, USGS, universities, and other organizations having NURE contracts. Bendix does most of the planning for NURE under the guidance of the Project Office. The Bendix effort is organized into a Geology Div., a Data Acquisition and Development Div., an Advanced Technology Div., and a Planning and Information Systems Div. Bendix currently employs about 430 people.

The NURE program administrators are now giving emphasis to completion of an in-depth evaluation of all areas for which preliminary estimates of uranium potential have already been made. The plan is to produce a report by 1982 that will assess the priority areas of the US, with interim reports to be issued yearly. The first interim report is scheduled to appear early in 1979. Assessment of areas that seem less favorable for uranium development is planned for completion by 1984.

Funding for NURE rose from \$33 million in fiscal year 1977 to \$55 million in fiscal 1978, and it is planned at \$78 million for fiscal 1979.

For the purposes of the NURE survey, the US has been divided into 621 quadrangles, 1° by 2°. Of these, 272 are receiving priority coverage by six geophysical service companies, which are flying aerial radiometric surveys on flight lines averaging about 5 mi apart. As of March 1, 1978, 450,544 line miles had been completed, data for 62 quadrangles had been placed on open file, and flying was complete for 128 quadrangles and was in progress for seven quadrangles.

The NURE project also encompasses hydrogeochemical and stream sediment sampling, geologic studies, and geostatistical investigations. A substantially increased drilling program is planned, to improve the reliability of uranium resource estimates. □

Union Carbide: Mainstay of western Colorado production

UNION CARBIDE OPERATES two processing facilities in western Colorado—a uranium mill of about 1,250-tpd capacity at Uravan and a heap leaching operation at Maybelle. At the latter, ore is layered in 300,000-ton heaps, and leaching, which cannot be done during the winter, proceeds for seven or eight months of the year. Uranium is recovered from the leach solution by a moving-column ion exchange plant, yellowcake is precipitated from the solution, and the product is shipped to Union Carbide's Gas Hills, Wyo., mill for reprocessing. The Gas Hills plant is also the site of a heap leaching facility.

The company has no current plans for expansion at Uravan, but it is developing a promising deposit in the La Sal district in Utah that might, according to some observers, become the basis for a new mill. The Uravan mill extracts both uranium and vanadium from the ores of about 20 mines. Fifteen of the mines are operated for Union Carbide by contractors, with the number of employees at each mine ranging from two to 20. Union Carbide itself operates the Deremo, King Solomon, and Sunday mines in Colorado and the La Sal and Wilson mines in Utah.

In the course of its history, the Uravan mill has processed ore from more than 200 mines, with individual mines delivering from as little as 100 tons to more than 1 million tons. Union Carbide credits the early small-mine operators for much of the development of trackless

underground mining methods now in use in the district. The five mines operated by Union Carbide currently supply about 85% of the Uravan mill feed.

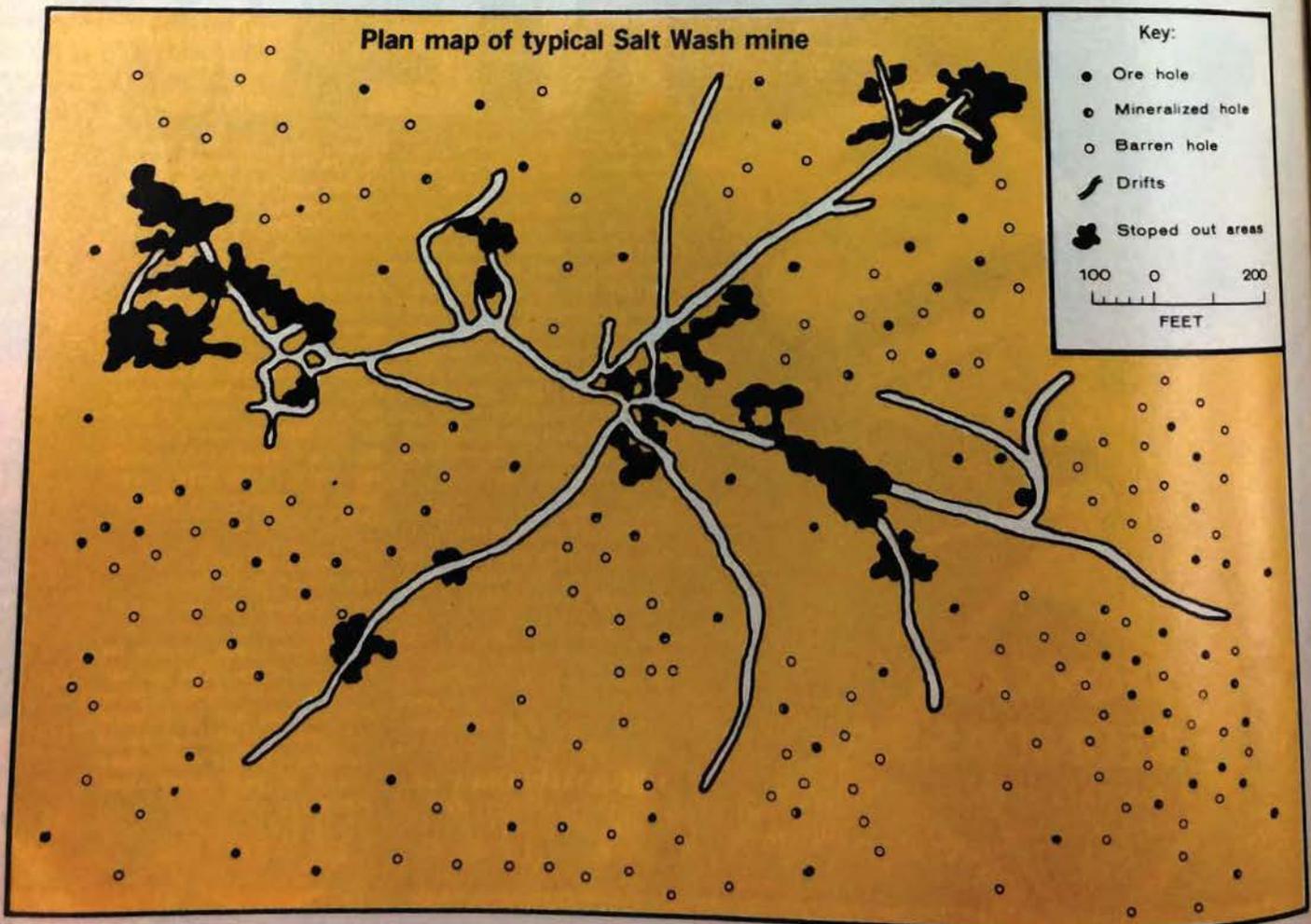
Before development begins, Union Carbide mine planners analyze six alternatives for mine entries: vertical shaft, trackless decline, track decline, level trackless adit from a canyon wall, track adit, and decline or adit fitted with conveyor belt. Vertical shafts are favored when ore depths are over 500-600 ft and no canyon wall is near enough for adit entry. Trackless declines, limited to about a 12% slope, stretch out the time required for development, but capital cost on the surface is lower with declines than with shafts. The major disadvantage is high maintenance costs for the decline through long stretches of the Brushy Basin mudstone.

When a canyon wall exposes the host Salt Wash sediments in proximity to the ore, an adit is usually the best means of entry. Since all haulage from the face is then trackless, there is little merit in transferring muck to rails for movement from the mine.

Union Carbide has considered conveyor belt mainline haulage, but high capital costs for such installations have been a deterrent.

Trackless mining at Union Carbide

Mining procedures in the Uravan district vary—often quite markedly—from one mine to the next, and opera-



tors caution that generalizations are subject to many exceptions. However, a good picture of mine practice in the district is provided by "Trackless Mining at Union Carbide's Operations in the Uravan District in Southwestern Colorado and Southeastern Utah," by G. J. Harvey Jr. The following description of mining in the district draws primarily on Harvey's paper, which was presented at the First Conference of Uranium Technology, held at the University of Nevada in April 1977.

Individual orebodies in the Uravan district meander in horizontal as well as vertical planes. Thickness varies, but "high-grade" ore seams average 3½ ft and usually do not exceed 8 ft. Other deposits are lenticular, with thicknesses up to 8 ft, widths up to 50 ft, and strike lengths up to 200 ft. The floors and backs undulate and may contain ore-in-waste pockets that must be found by test holing. Occasionally, two deposits at different elevations occur very close to each other or even overlap each other.

Compressive strength of the host rock varies from nil to more than 20,000 psi but is more commonly in the range of 12,000-18,000 psi. When not complicated by the presence of mudstone splits and fractures, it is self-supporting over widths of 30 to 40 ft. Shafts or declines to the host sandstone must pass through the Brushy Basin mudstone, which is self-supporting only over narrow widths. Openings large enough to accommodate mobile production units may require complete roof support with timber or steel.

"The generalized terms used to describe the Uravan mining methods are 'open room with random pillar,'" Harvey states. "The mining of ore is started on either an outcrop (rare occurrence at this late date) or at an ore intercept in an exploration hole at the terminus of the entry. Development then generally progresses along the ore trend, with attempts being made to stay in ore. As the orebodies broaden beyond 20 ft in width, and depending on roof conditions, pillars are left wherever possible in waste or low grade.

"Other than leaving pillars, roof support is adequately maintained by emplacement in random patterns of Scott "Split-Set" tubes, 4 to 6 ft long. Rarely is timber or steel support needed except when overlying sandstone contains mudstone splits, which must either be removed or supported with timber or steel sets and lagging. Occasionally, roof bolts with landing mats and/or real-lock fencing can be used to safely support back and walls in these cases.

"Underground declines with maximum grades of 12½-13% are the primary means of changing working elevation necessitated by fast-plunging or multihorizon orebodies. Others in the district use grades of up to 20%, but UCC operators have avoided these excesses because most of their mines have sufficient water to make traction somewhat of a problem on the steeper tramming grades.

"Roadway maintenance has evolved from doing nothing, to surfacing with mine waste, to surfacing with crushed gravel. Some chemical application has been tried with moderate success. Small sections of asphalt

have been laid down, but evaluation of this is not complete.

"Most mines have commercial electric power service, but occasionally in a remote mine with small ore potential, diesel power plants are used to generate power for driving ventilation fans and for other minor uses."

Evolution of mining methods

Trackless equipment was introduced in the Uravan district in the 1950s, with 1- to 3-ton haulage units loaded by track-mounted loaders. The first rubber-tired loader used successfully at Union Carbide mines was the Melroe "Bobcat." From 1962 to 1970, the Bobcat paired with 3-ton-capacity "Young Buggies" or Getman "Scooteretes" were the mainstays for loading and moving rock in stoping areas. Track haulage was still the main method of transport over longer hauls to shaft hoisting stations or to the surface.

Modified farm tractors pulling mine-made trailers came into use in the 1960s and demonstrated their usefulness for long-distance trackless haulage, although poor traction limited grades to 7-8%.

Union Carbide introduced the prototype of Eimco's 912 2-yd LHD into the Martha Belle mine in 1967, and the company soon put 12 of the units to work in its various mines. The 912s were used for hauls of up to 1,400 ft (beyond which productivity dropped to unacceptable levels) and to load 5-ton-capacity Young Buggies. Subsequently, 1-yd Eimco 911s were introduced and proved to have some advantages over the 2-yd machines. They could load 5-yd haulers while operating in a more confined space and having better capability for cleaning faces than the larger machine. The 1-yd loader and 5-yd hauler remain standard equipment in Union Carbide mines.

As workings moved farther from shafts and dump points, the company sought larger haulage units. In 1974, a 10-ton Eimco hauler began working in the Deremo mine with outstanding success, and in 1976, Union Carbide purchased eight more of these units.

Jacklegs are the main drilling tool in the district. "As many as six different drill machine manufacturers are represented in the many hundreds of drill machines in the district," according to Harvey. "Since the rock is somewhat soft and rounds are drilled rather rapidly, there was little interest in working with drill jumbos, and drilling methods have not kept up with the advancements in the loading and hauling systems. In addition, the rather erratic behavior of the ore occurrence has been a deterrent in drilling deep rounds in the ore faces. Obviously, a 10-ft vs. a 6-ft hole can seriously increase dilution because of the increased chance of penetrating waste rock."

In development headings, the economics of drill jumbos are more attractive. In 1972, a new boom was fitted with a used 3½-in. drifter and mounted on a 3-ton Young Buggy running gear. The unit proved effective. Later, Union Carbide mounted single booms with 5-in. valveless drifters on 5-ton Young Buggies, and these

Colorado-Utah

jumbos now commonly drill out 10-ft-deep development rounds.

Two-boom jumbos have not been considered, because one man cannot handle the rapid drill rates achieved. Drilling speeds are 4-8 ft per min when drilling 10-ft holes.

ANFO is used at the rate of 3.4-4 lb per ton of rock broken, with the relatively high rate being attributed to the high incidence of small headings. ANFO is detonated with 1-in. x 8-in., 60% dynamite cartridges, and a 6X cap and fuse are used to initiate the blast.

Ventilation of increasingly complex workings has called for ever larger vent raises. Drill equipment has changed from churn drills capable of producing 36-in.-dia holes to raise borers, often contracted from raise boring specialists. Union Carbide has purchased an Ingersoll-Rand RB-6 capable of backreaming 84-in.-dia holes. In 1976, the machine was used to drill 6,400 ft of hole, and more recently it has averaged up to 1,300 ft per month. The average penetration rate for the 11-in. pilot bit has been 20 ft per hr, and the backreaming rate to an 84-in. diameter has been about 14 ft per hr.

Two Union Carbide mines

The Deremo mine, 80 mi by road from the Uravan plant on the Colorado-Utah state line, is serviced by three 750-ft-deep vertical shafts, the oldest having been in service since 1958. A crew of 115 produced 103,000 tons of ore and 90,000 tons of waste in 1976, using rubber-tired equipment for all haulage from face to shaft station. Overall productivity was 6.9 tons per man-shift, while that of production crews was 24 tons per man-shift.

Two Eimco 912s were used primarily for loading in development drifts, and the cost to operate and maintain the eight-year-old units, usually working long hauls, averaged about \$2.01 per ton of ore and waste, excluding operator costs. Operation of 10 Eimco 911s and two Wagner ST1B LHDs used primarily in stope loading cost 51¢ per ton of ore and waste, excluding operator costs.

For three Eimco 980 trucks averaging 9.0 tons per load at hauls averaging 3,000 ft, operating and haulage costs, per ton of rock, were: fuel, 7.8¢; tires, 4.2¢; servicing, 19.5¢; repair labor, 7.4¢; and repair material, 3.5¢. The total is 42.4¢ per ton of rock.

Eleven tractor-trailer units, usually operating over

medium-length distances, yield an operating and maintenance cost of 94¢ per ton of rock at 5.8 tons per trip.

Two 5-ton Young Buggies used in cleanup mining on short hauls at 4.1 tons per trip cost \$1.26 per ton to operate.

There are 80 jacklegs in the mine and one single-boom drill jumbo. A used Allis-Chalmers Model W grader was purchased in 1971 for underground maintenance.

Union Carbide's new King Solomon mine has become a showcase for innovative mining methods developed at other mines. Located on Atkinson Mesa, 6 mi north of the Uravan mill, the orebodies were leased to Union Carbide by the Energy Research and Development Administration in 1974. No development had taken place on the property before that date, but ore occurrences were known to exist at three underground locations within its boundaries.

Union Carbide mine planners elected to reach the ore by a trackless decline, and construction crews broke ground for surface facilities in February 1975. The approach required driving 1,250 ft of decline on a 12% slope, with steel sets and lagging used to support about 600 ft of the total in the Brushy Basin shale. In August a breakthrough to an old adit from the rim provided an opening for ventilation, an escapeway, and access to the Two-yard-capacity LHDs accomplished most of the mucking and hauling in the decline before a 5-ton Young Buggy was added for hauling. In 1975, Union Carbide miners drove 4,990 ft of drift and in 1976, 9,700 ft of drift, with additional connections being made to the Worcester and Golden Cycle mines. At midsummer 1978, 19 men were working underground in two shifts producing 500 tpd.

Production equipment at King Solomon includes 1- and 2-yd-capacity LHDs, three 5-ton-capacity Young Buggies hauling 4.5 tons per trip, three T-980 Eimco trucks hauling 8.4 tons per trip, and a complement of push feed drills. A single-boom jumbo with a 5-in. valveless drifter on a 5-ton Young Buggy frame performs the development drilling.

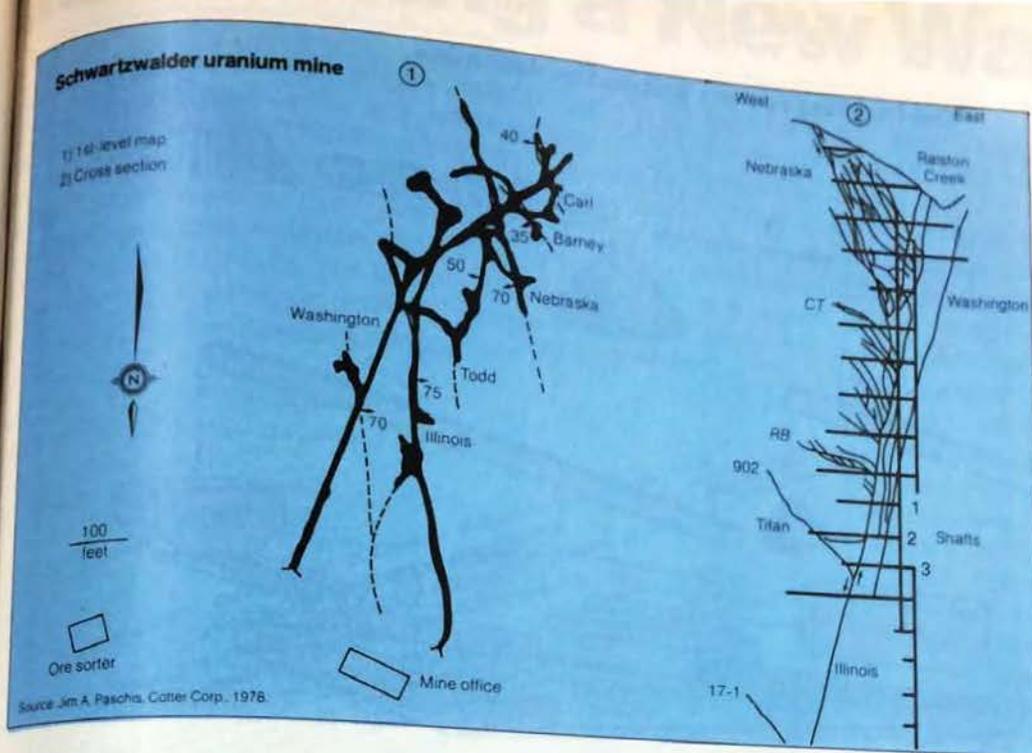
Straps and mesh are used for roof support. The mine is so dry that water must be trucked in for drill water and other uses.

Early performance at King Solomon is considered very good. For example, productivity of miners reached 30.7 tons per man-shift during December 1976, while overall productivity reached 15.6 tons per man-shift. □

Cotter Corp. moves ahead on several fronts

A \$30 MILLION EXPANSION of the uranium-vanadium mill at Canon City, development of several small mines on Department of Energy leases in the Uravan mineral belt, and continuing production at the primary-vein Schwartzwalder uranium mine about 8 mi northwest of Golden, Colo., highlight the activities of Cotter Corp., a wholly owned subsidiary of Commonwealth Edison Co., of Chicago.

Expansion at Canon City will triple ore processing capability to 1,200 tpd through an alkaline leach circuit which will accept feed both from the Schwartzwalder and from Cotter's western Colorado mines. Included in the construction program, which is being performed by Mountain States Engineers, will be a \$7 million tailing dam and reservoir that has been subcontracted to Standard Construction, of Grand Junction, Colo.



Early in 1978, Cotter also started up a 60-tpd spent-catalyst processing plant at Canon City. The facility incorporates ammonium carbonate and sodium hydroxide leach circuits capable of recovering a variety of metals—including nickel, tungsten, and vanadium—from spent catalysts.

Cotter's western Colorado mining properties are being developed by Dave Blake, an independent mining contractor based in Nucla, and other contractors. Blake's work at the Long Park No. 21 mine, which will produce 150 tpd, provides a fine illustration of how modern trackless mining equipment can be successfully applied in a small-scale operation. Included on the Long Park No. 21 equipment list are two 10-ton-capacity and one 13-ton-capacity Eimco rear-dump trucks that transport ore and waste to the surface via a 1,850-ft decline, a single-boom Gardner-Denver drill jumbo mounted on a "Young Buggy" chassis, and a Case 950 tracked loader. An Ingersoll-Rand raise borer owned by Union Carbide was contracted to open a ventilation raise, and a Dosco continuous miner owned by Cotter Corp. was used to drive the 10 x 11-ft decline. The decline is shotcreted throughout its length to protect against air slack.

Mining the Schwartzwalder vein deposits

Cotter Corp. acquired the Schwartzwalder mine near Golden in 1965, when the operation was producing about 70 tpd of ore. Production from steeply dipping veins of relatively small horizontal extent has since expanded to 600 tpd—the maximum possible using currently installed hoisting capacity.

The uranium mineralization of the Schwartzwalder was discovered in 1949 when a malachite sample, found at a vein outcrop by a rock hound name Fred Schwartzwalder, yielded a sharp geiger response. Schwartzwalder

returned to investigate the area, which had been known as a copper prospect since the late 1800s. Using secondary copper minerals as a uranium guide, he discovered first a geiger response, then fluorescent secondary uranium minerals, and soon after that pitchblende. Details of the deposit's discovery, geology, and development are discussed in "Mining and Geologic Developments at Cotter Corp.'s Schwartzwalder Uranium Mine, Jefferson County, Colo.," a paper by Jim A. Pachis, Cotter's Front Range district geologist. The paper was presented at the 14th International Minerals Conference of AIME in Vail, Colo., Aug. 11, 1978.

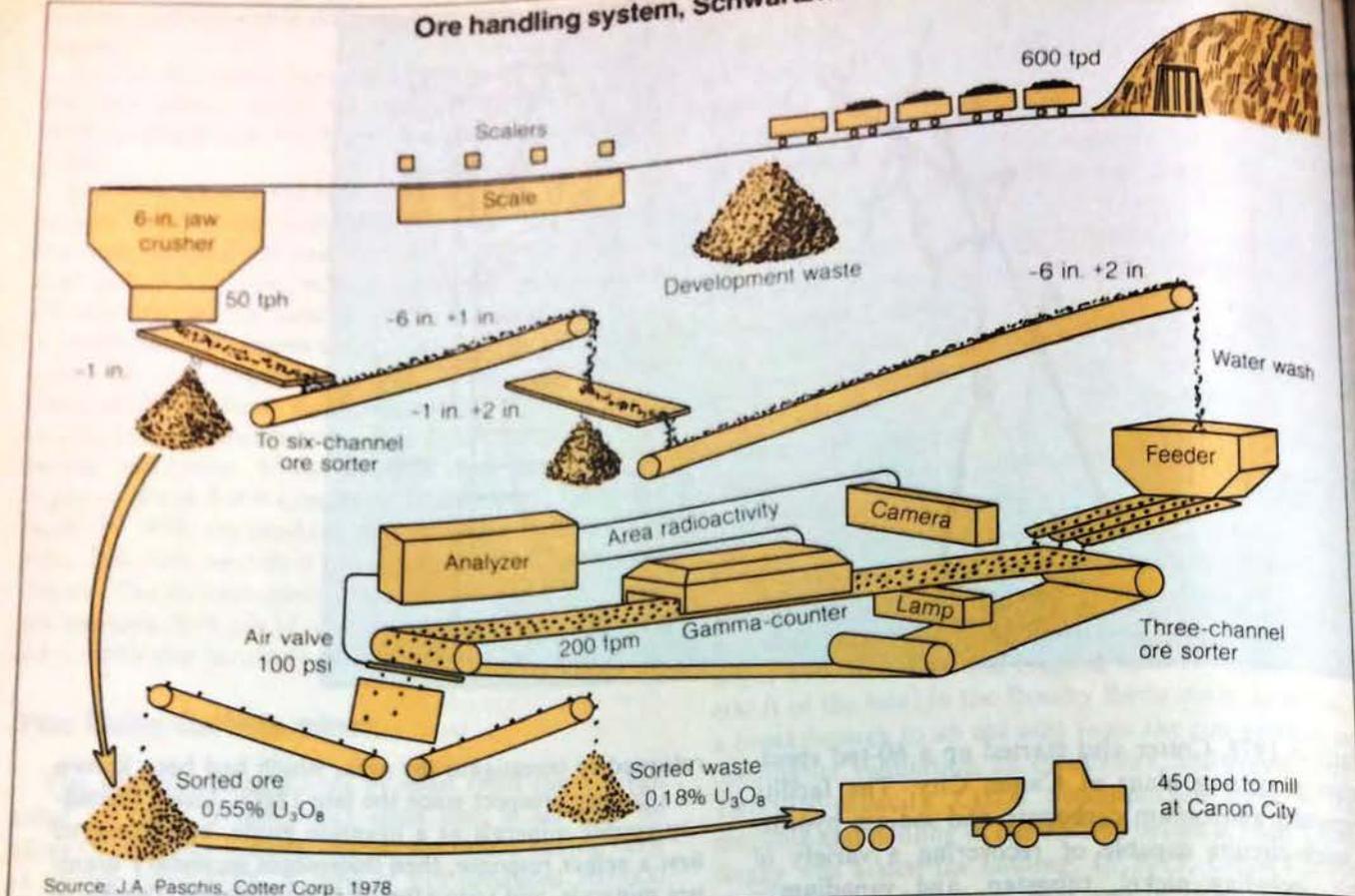
The locally mineralized, steeply dipping Illinois fault hosts the Schwartzwalder ores. In the mine, the fault can be seen as a breccia structure with mineralization on the second level, as an unmineralized shear zone on the ninth level, and as a mineralized coarsely crustified open fault with post-pitchblende calcite on the 11th level. The ore strike length is unusually short in comparison with the mineralized dip length, Pachis observes, demonstrating the critical importance of wall rock control and forewarning the exploration geologist. (See diagrams.) The source of the mineralizing fluids remains unknown.

Cotter is operating two 1,000-ft-capacity Diamec exploration drills at the Schwartzwalder. For every foot of rock cored, the drills reveal about 100 lb of U_3O_8 .

Mining operations currently deliver a product grading 0.32% U_3O_8 to an ore sorting plant at the surface, where it is upgraded to 0.55% by two photoradiometric ore sorters.

Three internal shafts provide access to the Schwartzwalder stopes: the No. 1 shaft, which is now used only as an escape route; the No. 2, with two 60-in. compartments covering a vertical distance of 1,300 ft; and the No. 3, with two 72-in. compartments covering a distance of 1,000 ft (see mine cross section). Twenty levels at

Ore handling system, Schwarzwaldler mine



100-ft vertical intervals extend downward from the surface to an elevation of about 4,430 ft. Development crews are currently opening the 16th level using a jumbo for drilling.

Shrink stope methods, with jacklegs and stopers for drilling, are used to extract steeper veins. Slushers, trackless loaders discharging into Young Buggies, and 1-cu-yd-capacity front-end loaders expedite transfer of ore and muck to ore passes.

In the steep, wide areas of the Illinois vein and in some other areas of the mine, Cotter crews make use of an "Air-Trac" down-the-hole drill. After charging down-the-hole patterns with ANFO, the production crews "bulk"-blasted them, leaving ore and waste combined.

After mining terminates in a vein, stopes are sealed off to prevent the escape of radon gas and to streamline the mine ventilation. About 250,000 cfm of air is downcast through the shafts by 75-hp fans. The air exhausts through an 8-ft-dia, 2,500-ft-deep ventilation raise completed in 1977 by using a Robbins raise borer.

Radiometric sorter boosts grade

At the Schwarzwaldler surface plant, scalers first determine whether mined rock passes the cutoff grade. If so, the ore car proceeds to the mine's unique ore sorting plant, which came on stream three years ago.

A jaw crusher reduces the rock to minus 6 in., and it is then screened to separate minus 1-in. material. This

fraction assays about 25% more U_3O_8 than the plus 1-in. fraction, and it is not treated further. Another screening creates plus 2-in. minus 6-in. and plus 1-in. minus 2-in. fractions that are conveyed separately to two photoradiometric ore sorters. Before entering the sorter, the plus 2-in. fraction is washed to remove fines that might cause contamination.

A feeder arranges ore particles in three lines on a conveyor belt that advances at 200 ft per min through the ore sorter (see diagram). As the translucent belt passes over a light source, a camera above it identifies each particle by shape and location, and an analyzer computes the area of the shadows cast by the ore particles. The belt then advances through a shielded gamma counter that measures the radiometric value of each particle. The analyzer then computes the gamma count per unit area. If the count is below the selected cutoff grade, the particle drops from the end of the belt and is conveyed to a waste pile. The waste grades only 0.018% U_3O_8 . If the count is above the cutoff grade, the analyzer activates and times the discharge of 100-psi air jets that blow the particle away from the falling stream of waste particles to a sorted-ore belt.

About 450 tpd of sorted material grading 0.55% U_3O_8 is trucked to Cotter's Canon City mill. The Btu content of a day's production at the Schwarzwaldler, Pachis notes, is sufficient to generate the electric power requirements of the Denver metropolitan area for three days. □