



SURVEY NOTES

Vol. 11, No. 2

Service to the State of Utah

May 1977

DROUGHT HALTS LAKE RISE

Great Salt Lake levels recorded (in feet above sea level) this winter and spring by the U. S. Geological Survey are:

Date	Boat harbor (south arm)	Saline (north arm)
February 1	4,200.50	4,199.10
February 15	4,200.60	4,199.20
March 1	4,200.65	4,199.25
March 15	4,200.75	4,199.25
April 1	4,200.75	4,199.30
April 15	4,200.75	4,199.30

The level of the south arm stood .10 feet lower on April 15, 1977, than on the same date in 1976. The lake has risen only 0.45 foot since the seasonal low level measured on November 1, 1976. Average rise to the spring peak is 1.7 feet; however, in recent years the rise has exceeded 2 feet.

Ancient Fossil Find

A paper by H. J. Hofmann of the University of Montreal, Quebec, Canada, published in *Precambrian Research*, v. 4, p. 1-11, 1977, describes the first identified fossils found in the Uinta Mountain Group. Specimens of the microfossil, *Chuaria*, were found in outcrop samples of the Precambrian Red Pine Shale from Yellowstone Creek on the south flank of the Uintas. In a paper in the Spring 1975 issue of *Utah Geology*, Crittenden and Peterman assigned an age of 950 million years to the Red Pine Shale on the basis of whole rock Rb/Sr analysis of samples from a well on the north flank of the Uintas.

The paper by Hofmann, "The problematic fossil *Chuaria* from the Late Precambrian Uinta Mountain Group, Utah," describes and illustrates the fossils in detail and relates them to occurrences of *Chuaria* in post-Middle Proterozoic rocks elsewhere in the world.

Geological Matters . . .

Legislature Acts On Earthquake Hazards

Utah's 42nd Legislature adjourned March 16 after 60 busy days considering dozens of bills and resolutions related to natural resources and passing a few of significance to the Utah Geological and Mineral Survey.

Three bills that came to be known as the earthquake hazard reduction package were enacted into law. The most important of these to UGMS was House Bill No. 48, sponsored by Representative Genevieve Atwood (Salt Lake City) and Ray Nielsen (Fairview), which added to the statute governing UGMS the specific objective: "(6) to assist local and state government agencies in their planning, zoning, and building regulation functions by publishing maps delineating appropriately wide special earthquake risk areas and, at the request of state agencies or other governmental agencies, review the siting of critical facilities."

A total of \$48,000 was appropriated with this bill to add a geotechnical engineer and an engineering geologist to the UGMS Urban and Engineering Geology section which will undertake this work. Recruitment of these persons will begin soon so that actual work can start shortly after July 1, the beginning of the new fiscal year. The original budget request of \$125,000 would have provided funding for at least three additional employees and a more extensive mapping program of earthquake risks than is possible with the reduced appropriation.

House Bill No. 46, also sponsored by Representatives Atwood and Nielsen, creates a seismic safety advisory council and sets up a small organization under an executive director to review and coordinate all seismic safety programs in the state and to advise the governor and legislature on needed administrative action

and legislation for earthquake hazard reduction. A supplemental appropriation of \$80,000 was provided for the new organization, which will be housed in the USGS building for the present.

House Bill No. 47, introduced by Representatives Nielsen and Atwood and Dewain C. Washburn (Monroe) and Edison J. Stephens (Henefer), removes an exemption in effect at present and gives the Division of Water Rights (State Engineer) approval and inspection powers over dams built and operated by the U. S. Bureau of Reclamation. The momentum for passing this bill was generated by the Teton Dam disaster in Idaho in June 1976.

Among other legislation directly concerning UGMS was Senate Bill No. 138, sponsored by Senators Beck (Kearns), Snow (Provo), and Bunnell (Price), which changed the method of distributing revenues derived by Utah from the federal government's Mineral Leasing Fund. UGMS will no longer receive part of its monies as a percentage of this fund, an amount which varied considerably from year to year, but will receive a fixed amount to be appropriated each year. A thorny budgetary problem for UGMS has been eliminated.

Other bills of natural resource or geological importance increased the powers of the Division of Oil, Gas and Mining in the statutory pooling of oil and gas interests in drilling units, created an energy conservation and development council for the state, and included protection and preservation of paleontological objects under the state antiquities act. This last piece of legisla-

(continued on page 13)

SURVEY RELEASES LATEST STUDIES

The latest publications of the Utah Geological and Mineral Survey are available through the UGMS Publication Sales Office, 606 Black Hawk Way, Salt Lake City, Utah 84108. When ordering by mail, add 10% for handling and mailing charges—minimum charge is \$.25. Mailing charges for maps may vary: see listing of maps for prices.

Utah Geology, Vol. 4, No. 1, Spring, 1977. Published biannually. Subscriptions are \$6.00 per year. Single issues are \$3.50. Handling and mailing charges are included in the subscription price. This issue contains the following articles: "Subdivisions of the Major Physiographic Provinces in Utah," by Wm. Lee Stokes; "Heavy Metals in the Great Salt Lake, Utah," by Paul L. Tayler, Lynn A. Hutchinson, and Melvin K. Muir; "Occurrence of Petrified Wood in Coal, Kane County, Utah," by H. H. Doelling; "Pleistocene Volcanic Ash Deposits in Utah," by W. P. Nash and Rebecca Pope Smith; "Approximation of Magnesium Concentration by Refractive Index Measurements in Evaporating Brines of Great Salt Lake, Utah," by J. Wallace Gwynn and Paul A. Sturm; "The Boundary Between Uintah and Grand Counties, Utah," by Howard R. Ritzma; "Earthquake Epicenters in Utah January-June 1976," by Kenneth L. Cook; and "Classification of Ripple Marks," by Lee R. High, Jr. and M. Dane Picard.

Map 42, Earthquake Fault Map of a Portion of Salt Lake County, Utah, revised by Bruce N. Kaliser from Map 18 (originally issued in 1968). Printed on 8½" by 11" sheet. Map is free upon request. Mailing charge is \$.25.

Map 43, Physiographic Subdivisions of Utah, by Wm. Lee Stokes (\$.25; cost by mail is \$.50). Reprinted from Wm. Lee Stokes' article, "Subdivisions of the Major Physiographic Provinces in Utah," in *Utah Geology*, Vol. 4, No.1, Spring 1977. Map is printed in three colors on 8½" by 11" sheet.

Reprint 100, Satellite Microwave Observations of the Utah Great Salt Lake Desert, by Fawwaz T. Ulaby, Louis F.

(continued on page 13)

DIGGINS'

Arizona Minerals

The University of Arizona Press has published *Mineralogy of Arizona* by John W. Anthony, Sidney A. Williams, and Richard A. Bideaux. Most of the volume is a catalog of Arizona minerals and their occurrence listed by counties and mining districts or localities within counties. In addition, there are short sections on porphyry copper, porphyry copper-related, and uranium-vanadium mineral deposits. There is also a short article on the minerals formed by the United Verde mine fire at Jerome and a listing of meteorites found in the state. A comprehensive bibliography lists about 1,000 references. The final pages of the volume are index maps locating 246 mining districts and localities within Arizona. Many vivid color illustrations add greatly to the attractive appearance of this volume.

Mineralogy of Arizona (256 pages) is available from the University of Arizona Press, Box 3398, Tucson, AZ

85722. Cost is \$9.75 (paper back) and \$22.50 (cloth bound).

Gas and Oil on BLM Lands

According to *BLM Facts & Figures, 1976*, production in Utah for 1975 on BLM-administered lands accounted for 10 percent of the state's natural gas, 15 percent of its oil, 37 percent of its coal, and all its carbon dioxide.

Appointment

The Secretary of the Interior, Cecil D. Andrus, announced on April 23 the formation of a committee that will look for ways to increase the production of natural gas from federal oil and gas leases on the Outer Continental Shelf. Dr. Charles J. Mankin, Director of the Oklahoma Geological Survey and President of the Association of American State Geologists, will serve as chairman. Dr. Mankin is well known to many geologists in Utah who wish him well in this endeavor.

Status of Topo Mapping

At the end of 1976, topographic map coverage in Utah was nearly complete, but large areas still remained to be covered by up-to-date 7½-minute quadrangles.

Status of quadrangles	7½-minute quadrangles completed	Area mapped (square miles)	Percent of State
7½-minute (published)	780	43,300	51.3
7½-minute (in process)	104 ¹	6,675	7.9
15-minute (published)	628 ²	34,500	40.8
Total	1,512	84,475	100.0

¹ Approximate number—includes some maps published and in various stages of completion.

² Four 7½-minute quadrangles equal one 15-minute quadrangle (157 fifteen-minute quadrangles).

From 1965 through 1972 (fiscal years), the Utah Geological and Mineral Survey contributed \$140,000 to the UGMS/USGS cooperative mapping project. Since 1973 the annual contribution has been \$50,000. The total contribution through fiscal 1976-77 has been \$470,000.

AAPG/SEPM DATES SET

Howard Ritzma, UGMS assistant director, took over duties as president of the Rocky Mountain Section, American Association of Petroleum Geologists, at the group's annual meeting in Denver in April. John Dahm, gas supply engineer with Northwest Pipeline, Salt Lake City, was elected secretary-treasurer.

The Rocky Mountain Section of AAPG and its affiliate, the Society of Economic Paleontologists and Mineral-

ogists, will meet in Salt Lake City, March 19-22, 1978. About 1,500 geologists and geophysicists involved in petroleum and other energy minerals are expected to attend the five days of scientific sessions, continuing education courses, and field trips. Host organization for the meeting is the Utah Geological Association. Co-chairmen of the 1978 meeting are Ed Keller, exploration manager for Mountain Fuel, and Stan Bardsley, vice-president of Skyline Oil.

UTAH MINERAL INDUSTRY ACTIVITY FOR 1976

by Carlton H. Stowe¹

VALUE OF MINERAL PRODUCTION

For the first time in Utah's mining history, mineral production exceeded the billion-dollar mark; it amounted to \$1,018,161,000 (table 1). When adjusted to the 1967 constant dollar (figure 1), the value of mineral production reached peaks in 1970 and 1974. Only modest gains have been made over average values recorded for 1958 to 1966.

Oil production dropped to 35,384,000 barrels from a high in 1975 of 42 million barrels. Gold production dropped from 189,620 ounces in 1975 to 184,565 ounces valued at a little more than \$22.7 million. Copper production rose to 185,760 short tons. Copper prices averaged just slightly more than 65 cents per pound, about two cents more per pound than in 1975 when production was 177,155 short tons. Coal production climbed from 6,961,000 short tons in 1975 to an all-time high of 7,700,000 short tons valued at \$162,000,000.

Other increases were noted: clays, \$633,000 (up from \$548,000 in 1975); gypsum, \$1,528,000 (up from \$1,457,000); lead, \$7,373,000 (up from \$5,452,000); lime, \$5,940,000 (up from \$4,540,000); natural gas, (\$33,598,000 (up from \$26,570,000); salt, \$10,280,000 (up from \$7,717,000); sand and gravel, \$21,523,000 (up from \$14,342,000); silver, \$13,144,000 (up from \$12,472,000); and zinc, \$16,395,000 (up from \$15,319,000).

Minerals placed in the "information withheld" categories by the U. S. Bureau of Mines include beryllium, magnesium, molybdenum, phosphate rock, potassium salts, tungsten, uranium, and vanadium. Total value of production for these was \$139,037,000 compared with \$116,550,000 in 1975.

Federal Lands²

The federal government controlled 68.1 percent of Utah lands, excluding

Indian lands; with Indian lands, the control was 72.5 percent. In 1975 the federal government controlled 66.6 percent and 70.9 percent of the land, respectively. Five years ago, the Bureau of Land Management administered 43.14 percent of Utah lands.³ In 1976, BLM administered 53.3 percent, or slightly more than 28 million acres of Utah lands. The division of federal, state, and private land ownership in Utah is shown in figure 2.

BLM had 15,093 leases totaling 15,834,278 acres under oil and gas per-

mits in 1976. Coal leases covered 265,452 acres, phosphate 8,800 acres, and geothermal 328,559 acres.

State Lands⁴

The Division of State Lands reported that mineral lease revenue on state land was \$4,550,421 compared with \$5,205,677 in 1975 (figure 3). Royalty revenue was \$2,325,418 compared with \$2,234,941 in 1975. Total collections of \$12,841,249 were \$859,200 more than in 1975, yet far short of the all-time high of \$22.6 million in 1974. Receipts totaled \$234,663 on sales of state-owned land,

³Source: *Quarterly Review*, Vol. 6, No. 1, February 1972: Utah Geological and Mineral Survey, p. 4.

⁴Source: State of Utah, Division of State Lands, *Fiscal Report July 1, 1975 to June 30, 1976*.

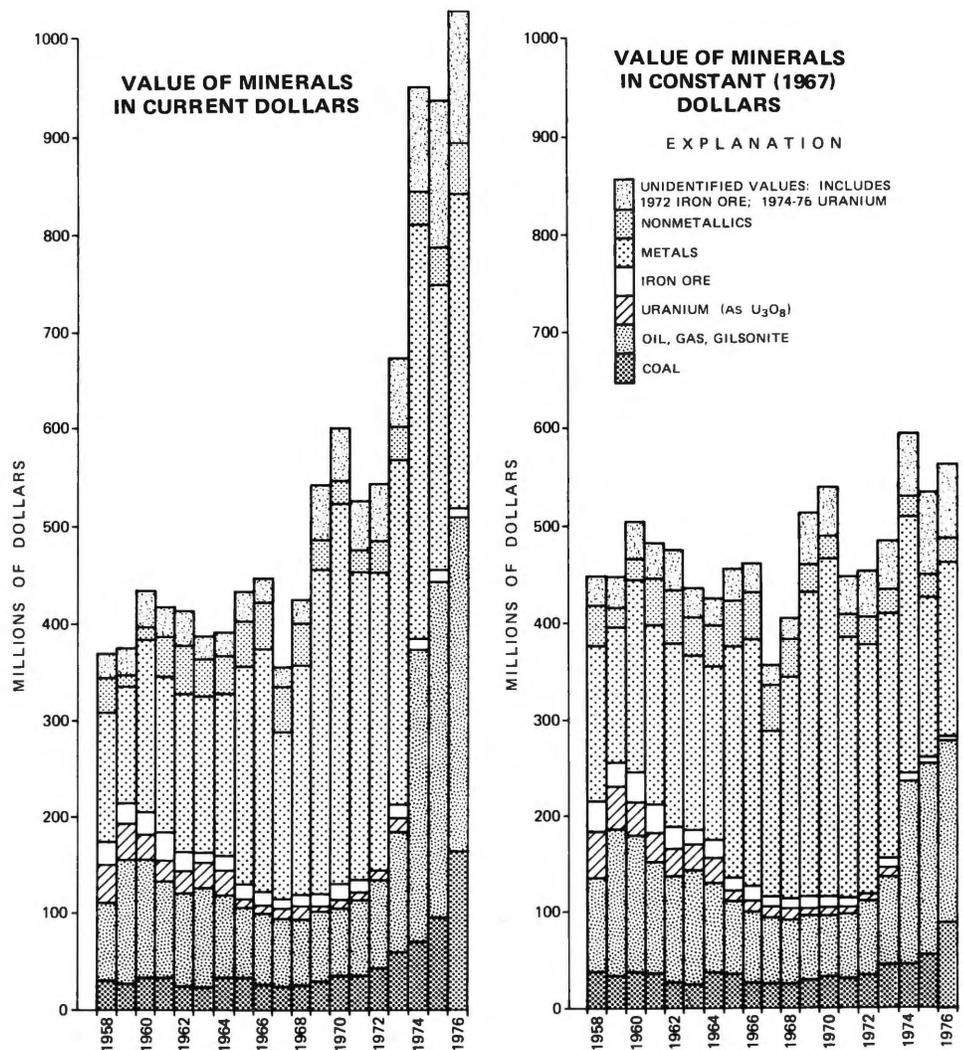


Figure 1. Value of Utah's mineral production, 1958-1976.

¹ Mineral Information Specialist, Utah Geological and Mineral Survey, Salt Lake City, Utah 84108.

² Source: U. S. Bureau of Land Management, *BLM Facts & Figures for Utah-1976*.

Table 1. Mineral production in Utah for 1975 and 1976.¹

Mineral	Unit of measurement	1975 ²		1976 ³	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Carbon dioxide (natural)	thousand cubic feet	108,941	\$ 8	110,000	\$ 10
Clays ²	thousand short tons	220	548	248	633
Coal (bituminous)	thousand short tons	6,961	138,134	7,700	162,000
Copper (recoverable content of ores, etc.)	short tons	177,155	227,467	185,760	260,064
Fluorspar	short tons	9,542	389	4	4
Gemstones		5	100	5	100
Gold (recoverable content of ores, etc.)	troy ounces	189,260	30,622	184,565	22,701
Gypsum	thousand short tons	247	1,457	220	1,528
Iron ore (usable)	thousand long tons, gross weight	1,334	10,399	1,260	10,365
Lead (recoverable content of ores, etc.)	short tons	12,679	5,452	15,965	7,376
Lime	thousand short tons	161	4,540	194	5,940
Natural gas	million cubic feet	55,354	26,570	55,904	33,598
Petroleum (crude)	thousand 42-gallon barrels	42,301	348,131	35,384	306,072
Pumice	thousand short tons	17	23	20	59
Salt	thousand short tons	631	7,717	700	10,280
Sand and gravel	thousand short tons	10,159	14,342	10,870	21,523
Silver (recoverable content of ores, etc.)	thousand troy ounces	2,822	12,472	3,008	13,144
Stone	thousand short tons	2,486	6,167	2,542	7,336
Zinc (recoverable content of ores, etc.)	short tons	19,640	15,319	22,155	16,395
Value of items that cannot be disclosed:					
Asphalt, beryllium, cement, clays (kaolin, 1975), magnesium compounds, molybdenum, natural gas liquids, phosphate rock, potassium salts, sodium sulfate, tungsten concentrates, uranium, vanadium, and values indicated by footnote 4.					
		6	116,550	6	139,037
Total		6	\$966,407	6	\$1,018,161

Source: U. S. Bureau of Mines annual preliminary report. Data compiled in cooperation with the Utah Geological and Mineral Survey.

¹ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

² Final yearbook figures.

³ Preliminary figures.

⁴ Withheld to avoid disclosing individual company confidential data; value included with "Value of items that cannot be disclosed."

⁵ Not available.

⁶ Not applicable.

rights of way, timber sales, and grazing lease rentals. Other items such as sale contracts, loans, bond interests, and special-use leasing brought Utah \$6,570,320.

The state had 3,089,848 acres under oil and gas leases. A total of 2,986,809 acres were under oil and gas leases in 1975. As in 1975, Box Elder County led in oil and gas leases with 428,421 acres. Grand County was second with 366,315 acres, followed by San Juan County, 291,197 acres, and Uintah County, 244,314 acres. Six other counties each had 100,000 or more acres under oil and gas leases. Other lease arrangements throughout the state were 935,636 acres for metalliferous minerals, 98,487 acres for nonmetallics, 27,229 acres for bituminous sands, 489,399 acres for coal, 207,100 acres for oil shale, 205,343 acres for salt, and 177,585 acres for geothermal energy.

EMPLOYMENT⁵

The mining and processing of energy minerals, metals, and nonmetals employed over 13,000 people in Utah, compared with 12,700 in 1970. During 1975, 13,100 people were employed with a payroll of \$185,121,967. Preliminary figures for 1976 indicated that 13,800 people were employed. The forecast for 1977 predicted an average of 15,000 people would be on mining industry payrolls. Layoffs in metal mining and oil exploration decreased the industry's job growth rate, but increased job availability is seen for 1977 particularly in coal mining. More than 3,200 employees were working in the coal mining industry of Utah. In crude oil and natural gas production over 2,600 persons were employed.

⁵ Source: Job Service (Utah Department of Employment Security), *Annual Report 1975*, September 1976, and *Employment Newsletter*, February 1977.

MINERAL PROPERTY VALUATION⁶

The assessed valuation of Utah mineral properties was \$501,433,798 compared with \$493,052,022 in 1975. Oil and gas valuation accounted for most of the gain, principally because of production at the Greater Altamont-Bluebell field in the Uinta Basin. The gain more than covered a drop in assessed valuation for the mining industry.

Overall valuation of the mining industry decreased from \$298.6 million in 1975 to \$266.9 million in 1976 caused mainly by a \$46 million decline in the assessed valuation of Kennecott Copper's Utah Copper Division. The mining valuation is based on a formula that averages

⁶ Source: Utah Geological and Mineral Survey statistical information from records of State Tax Commission, Mineral Property Division.

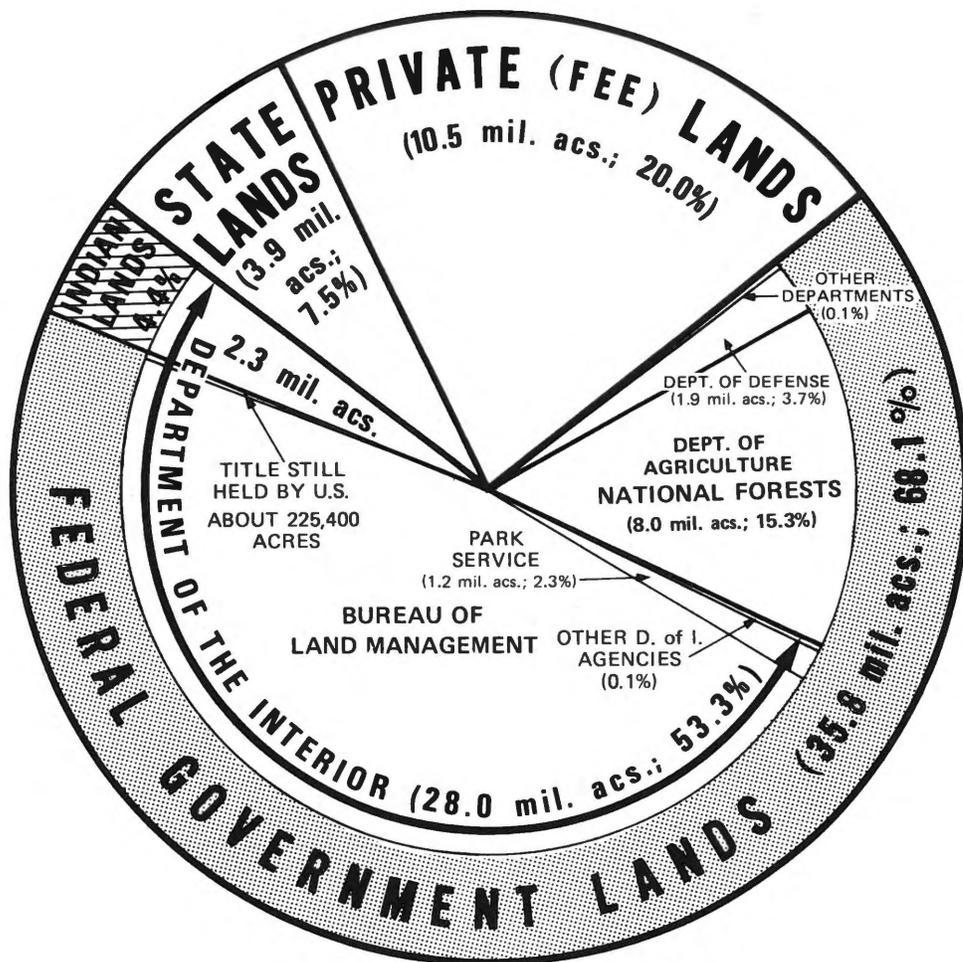


Figure 2. Utah land ownership.

	Millions of acres	Percent of land area
Federal Lands		
National Resource Lands (mostly BLM)*	23.7	45.1
National Forests (Department of Agriculture)	8.0	15.3
National Parks, Monuments, etc.*	0.8	1.5
Department of Defense	1.9	3.7
Glen Canyon National Recreation area	1.2	2.3
Others	0.1	0.2
Total Federal Lands	35.8	68.1
Indian Reservations*	2.3	4.4
State	3.9	7.5
Private	10.5	20.0
Land area of Utah (52,541,440 acres)	52.5	100.0
Water area of Utah (1,804,800 acres)	1.8	
Total land and water area of Utah (54,346,240 acres)	54.3	

*Department of the Interior.

coal production with slightly less than 80 percent of the coal produced.

In 1976, Utah consumed about one-half of the coal it produced. Of this, slightly more than 51 percent was consumed in Utah by electric utilities, while 23 percent was used by coke and gas plants. The remainder was exported to other states and to foreign users.

In June, Soldier Creek Coal Company, a wholly-owned subsidiary of California Portland Cement Company, commenced production at its mine in the Book Cliffs coal field, east of the Castle Gate area, following an extensive rehabilitation project. The mine, purchased from Premium Coal Company, had been idle since 1972. It will now furnish coal to three cement plants belonging to the parent company at Colton and Mojave, California, and Rillito, Arizona.

Utah Coal and Energy began constructing facilities at its Upton project near Coalville where a 10-foot coal seam in the Frontier Formation is expected to yield 30 million short tons. The coal will be trucked into Coalville where it will be transhipped to market by rail.

Valley Camp Coal Company started work on its No. 1 Belina mine in Carbon County that should increase the company's annual production to about 1.5 million short tons. Unit-train ship-

net proceeds of the taxed entity for three consecutive years, including the tax year.

Mine occupation taxes paid to the state totaled \$8,571,686. Of this oil and gas properties paid the largest share, \$6,613,121. Shell oil paid \$1,119,231 on its Altamont field production. Chevron Oil paid \$767,803 out of the Bluebell field. Texaco was third with \$745,015 from the Greater Aneth area.

Kennecott led the list for the mining companies with a \$1,588,003 tax on its Utah Copper Division properties. Rio Algom was second with \$83,279 on its uranium properties south of Moab.

UTAH MINERAL OPERATIONS

Beryllium

Brush Wellman planned to expand its beryllium extraction facilities at Delta, Millard County. A beryl ore-processing plant will be added at an estimated cost

of \$4.5 million, which will mean hiring eight to ten new employees. The present plant processes only bertrandite, a beryllium ore mined by the company in the Topaz-Spor Mountain area of Juab County. When the addition is completed, the plant will be the only one in the United States capable of processing both bertrandite and beryl ores. The company will close its beryl-processing plant at Elmore, Ohio, when the expansion at Delta is completed.

Coal

Utah's coal production rose from 6,961,000 short tons in 1975 to an all-time high of 7,700,000 short tons valued at \$162,000,000. In the last three years, Utah produced 20,519,000 short tons of coal valued at \$371,833,000. Cumulative coal production in Utah totaled 349,155,000 short tons valued at \$1,688,547,000. Historically, Carbon and Emery Counties have dominated Utah

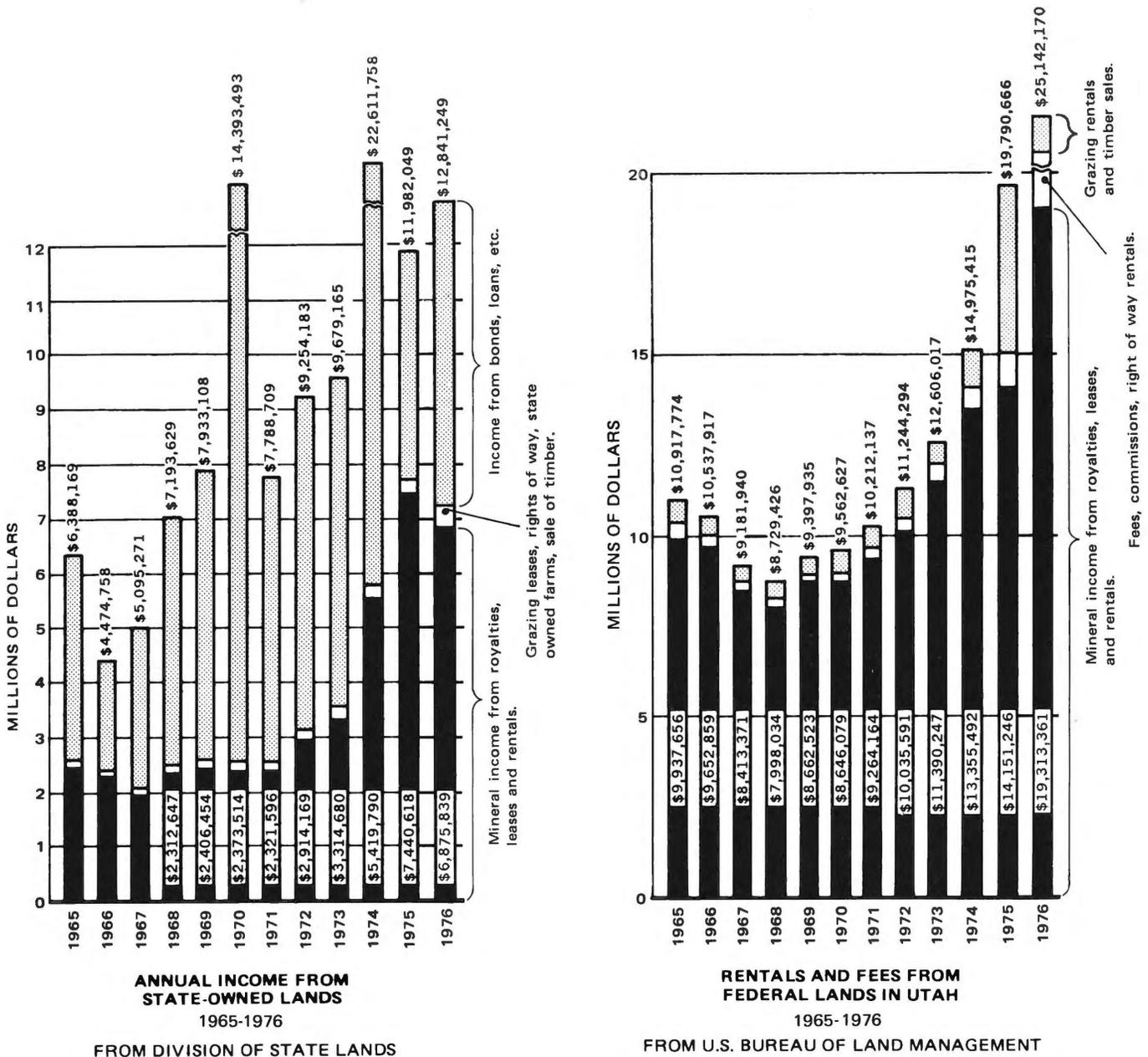


Figure 3. Source of income from Utah lands, 1966-1976.

ments of coal will be made from its Carbon County properties to Nevada Power Company's electrical generating plant at Moapa, Nevada. The schedule calls for shipment of 40 to 50 carloads each week.

The Thompson Canyon coal mine, 5 miles north of the Thompson townsite, Grand County, was recently reactivated by Wes-Pac Energy, a partner of Western American Energy Corporation. Production is expected to reach 350,000 short tons annually and to employ about 40 people by the end of 1977.

Swisher Coal Company submitted a proposal to the U. S. Department of the Interior to reopen the old Larson-Rigby coal mine. The mine is in Emery County on the northern end of Candland Mountain in upper Huntington Canyon about 25 miles northwest of Huntington, Utah.

A 7,600-acre tract of coal land in the Uinta Basin was purchased by Pacific Gas & Electric Company from Heiner Coal Company, a subsidiary of Island Creek Coal Company, for a reported \$10.7 million. The tract is estimated to contain between 150 and 200 million short tons of minable low-sulfur, high-Btu

coal. Sulfur content of the coal was reported to be under 0.5 percent enabling it to be burned directly as power plant fuel. The utility obtained the Utah coal for use in its proposed 800-megawatt power plant near the Collinsville area of San Francisco.

In August, General Exploration Company and Swisher Coal Company of Price signed an agreement to sell approximately 13 million short tons of Utah coal to a major Gulf Coast utility over a 15-year period. The Dallas-based coal, oil, and gas producer reported that initial deliveries will begin in 1978. The agree-

ment, without consideration being given to price escalation, represented sales exceeding \$250,000,000. Coal is to be supplied by Swisher's Gordon Creek and Huntington Canyon properties. The long-term contract provided for the renewal of two successive five-year periods after the initial 15-year agreement has been completed.

Clifford Minerals Corporation and Ivie Creek Coal Company arranged long-term leasing on 960 acres of coal lands owned by Ivie Creek in Emery County.

Intercoast Coal Company of Sacramento, California, purchased an extensive block of coal leases in excess of 40,000 acres in northern Grand County.

United States Fuel Company signed a new contract with Nevada Power Company to deliver from 6,350,000 to 8,100,000 short tons of coal to the utility at Moapa, Nevada, between January 1, 1977, and December 31, 1994. The new pact replaced an existing contract that called for purchases by Nevada Power of 400,000 short tons of coal per year through July 1, 1980, and for an option on additional coal purchases thereafter through 1994. As a result of the contract, U. S. Fuel planned to enlarge its coal-mining facilities and increase its employment in Carbon County from 200 to 300. The firm plans to open a major new mine, if it can secure an additional long-term contract with another purchaser.

In April, Southern California Edison, Arizona Public Service, and San Diego Gas and Electric abandoned plans to build a \$3.5 billion, three million-kilowatt electrical-generating plant on the Kaiparowits Plateau in Southern Utah, indicating that past and prospective delays had made its final cost untenable. In July, Southern California Edison Company and the two utility partners were considering the construction of a coal-gasification plant on the plateau. Subsidiaries of the three utilities applied to retain rights on 30,000 acre-feet of Utah's Colorado River water allocation. The retained water rights would allow them to develop a gasification plant and related facilities on Nipple Bench, a section of the Kaiparowits Plateau, about 15 miles from Page, Arizona. Details on the gasification plant's possible size or cost were not disclosed.

Copper, Gold,
Lead, Silver, and Zinc

The production value of copper, gold, lead, silver, and zinc was \$319,680,000 with copper making up the largest part, \$260,064,000. Copper production rose to 185,760 short tons. Copper prices averaged just slightly more than 65 cents per pound, about two cents more per pound than in 1975. Gold production dropped from 189,260 ounces in 1975 to 184,565 ounces valued at a little more than \$22.7 million. Lead production rose from 12,679 short tons in 1975 to 15,965 short tons, and zinc production reached 22,155 short tons compared with 19,640 short tons in 1975. Copper production averaged 15,066 short tons per month during the year.

Kennecott Copper's Tintic Division revealed that a new zone of copper, gold, and silver mineralization was found in the Trixie mine in the Burgin area. Kennecott also completed a 6-foot diameter ventilation shaft to the 1,300-foot level of the Burgin mine, permitting miners to work in areas of higher grade ore. Kennecott's Tintic Division, under a lease from Samuel and William McIntire, engaged in developmental work in the once-famous Mammoth gold mine in the Tintic district near Eureka. The mine, idle for 20 years, had produced \$20 million in gold, silver, copper, and lead. Kennecott uses dump material from the mine as a fluxing agent in the smelter at Magna.

Lead production in the state increased to 1,600 short tons monthly from just under 1,200 short tons monthly in 1974. Zinc production also increased to 2,800 short tons monthly from 1,550 short tons monthly in 1974.

The Anaconda Company appeared before the State Land Board in September to request a lease on parcels of state-owned land north of the Kennecott open-pit mine in Bingham Canyon that was needed for Anaconda's new copper mining and milling project—an undertaking which would exploit a new ore discovery more than 1,800 feet below the surface. Reserves being developed amount to 61.2 million short tons of ore, averaging 1.84 percent copper. Anaconda was sinking four shafts at the mine site and planning to begin the construction of the 10,000 tons-per-day mill in the summer

of 1977. Operations should begin in 1979.

Anaconda Company, as the majority stockholder, completed a merger with North Lily Mining Company to promote a comprehensive exploratory and developmental plan of the Tintic district holdings. The merger with North Lily Mining includes 15 other Tintic district mining companies. The companies merging with North Lily were Big Hill Mining, East Tintic Coalition Mining, Empire Mines, Eureka Bullion Mining, Mountain View Mining, The New Southern Eureka Mining, North Godiva Consolidated Mining, Swansea Consolidated Mining, Tintic Central Mining, Tintic Drain Tunnel, Twentieth Century Mining, Victory Consolidated Mining, Yankee Consolidated Mining, and ATC, Inc.

Geothermal

Phillips Petroleum planned to drill six new geothermal wells at the Roosevelt Hot Springs area, 6 to 8 miles northeast of Milford, Beaver County. Each well is scheduled to depths of at least 10,000 feet and are part of an overall drilling program calling for 16 wells on the Phillips' federal leases where the company has already completed six geothermal wells. Besides the Phillips Petroleum wells at Roosevelt Hot Springs, two new wells producing commercial quantities of steam were completed by Thermal Power Corporation.

Geothermal activities at Roosevelt Hot Springs and at other sites in southwestern Utah made Utah one of the busiest areas in geothermal exploration in the United States.

Two deep wells were completed near Beryl, and a third well was scheduled in the Lund-Avon area, Iron County. An unsuccessful test well was drilled east of Cove Fort, Millard County, by Union Oil, which had proposed 23 well sites in the valley east of Cove Fort and along the mountain front south of Sulphurdale. Phillips Petroleum also had proposed five well sites in the same general area. More geothermal drilling was scheduled in Utah for 1977. Several plans for operation on federal lands are pending before the U. S. Geological Survey.

Limestone

U. S. Steel Corporation, which for many years owned and operated a limestone quarry at Kegley, near Payson, and utilized powdered limestone and dolomite in the steel-making operations at its Geneva Works in Orem, was marketing a light-colored, pulverized limestone of face powder consistency to be used as a safety device in coal mines. When applied by rock-dusting machines or pneumatic conveying systems, it mixes with potentially explosive coal-dust particles, rendering them harmless. U. S. Steel expanded its sales of the rock dust to Wyoming and northern New Mexico.

Magnesium

National Lead Industries' Magnesium Division on the western shore of the Great Salt Lake undertook a \$30 million overhaul of the plant with the technical assistance of the Norwegian magnesium producer, Norsk Hydro of Oslo. It is expected that the company will be able to reach the originally scheduled capacity of 25,000 short tons of magnesium per year.

Potash

Texasgulf Incorporated's plant at Moab was temporarily shut down in December. The processing plant and harvest pond operations were to be closed until mid-April 1977. The company did not intend to lay off personnel. Mill and pond operations involve 25 people. The mill capacity was double what the ponds could produce for processing, and running the mill at half-capacity was not economical.

Kaiser Chemicals, a division of Kaiser Aluminum & Chemical Corporation, commenced surveying for a new \$3 million primary evaporating-pond system at its potash plant near Wendover to be completed in 1979. The new system will replace the existing network. The project covers about 1,000 acres.

Transammonia Incorporated of New York City applied to the U. S. Bureau of Land Management for permission to explore an area of Pilot Valley, 25 miles northeast of Wendover, Tooele County, to assess the value of potash resources. The firm hopes exploratory work would justify construction of a

potash-processing plant employing 50 to 75 people.

Uranium

Uranium production for Utah was not reported by the U. S. Bureau of Mines. Estimates indicated that production was about 7.5 thousand short tons.

The construction of a new circuit for processing uranium-vanadium ores at Atlas Mineral's mill at Moab was completed during 1976. An additional 30 jobs were made available.

Utah Power & Light Company continued its investigation into the ore potential of 300 claims in the Black Action group and Lark-Royal properties in San Juan County. Production at the Small Fry mine near Moab was started by Ranchers Exploration and Development Corporation. Approximately 18,000 short tons of ore was stockpiled by June. The operator planned to start operations in early 1977 at the Hope properties. Atlas Corporation signed a two-year agreement to supply Houston Lighting and Power Company with 1.25 million pounds of uranium worth approximately \$35 million.

Polaris Resources completed a preliminary 13-hole drilling program on its San Juan County uranium properties. The company has 10,000 acres in Juab County scheduled for exploration during 1977. The San Juan County property included 119 lode mining claims (approximately 2,300 acres) in the Uravan belt near La Sal Junction. Drilling established uranium deposits, but no estimates of reserves were made. Additional holdings included 500 claims between Topaz and Spor Mountains in west-central Utah including the Yellow Chief mine, where 290,000 pounds of U_3O_8 was produced in the 1950's.

Mineral Energy Incorporated of Orem agreed with Energy Fuels Incorporated of Denver to develop uranium properties in San Juan, Garfield, and Wayne Counties. Exploration and engineering operations on the leases were to be carried out with Energy Fuels purchasing all uranium ores developed. Mineral Energy also arranged with Phillips Petroleum to purchase 40,000 acres of uranium lands in San Juan County. In addition, three new mines by Mineral

Energy in the White Canyon mining district started production. Output from the mines was expected to be 2,000 tons of ore per month, containing between 6,000 and 8,000 pounds of U_3O_8 .

The construction of a \$6 million uranium extraction plant adjacent to Kennecott Copper Corporation's precipitation facilities near Copperton was announced in November. Wyoming Mineral Corporation of Littleton, Colorado, a subsidiary of Western Westinghouse Electric Corporation, will own and operate the facility under contract with Kennecott. The plant is scheduled to be in operation at the end of 1977. Thirteen persons will be employed. Wyoming Mineral plans to recover about 143,000 pounds of uranium each year through a precipitation process. At the current market value of about \$40 a pound, Wyoming Mineral should recover \$5.7 million worth of uranium annually. The process would be an adjunct to Kennecott's leaching and precipitation process for the recovery of low-grade copper from overburden.

Increased prices for uranium oxide during the year stimulated the filing of uranium claims throughout Juab, Wayne, Emery, San Juan, and Grand Counties. The Grand County Recorder's office noted that through November a total of 4,171 uranium-related papers were filed at the office compared with 4,092 during the same period for 1975.

Fuel Supply Services, Incorporated, a subsidiary of Florida Power and Light Company, signed an agreement with Getty and Skelly Oil companies to explore for uranium in Utah, Colorado, and New Mexico. The Utah claims were in Grand County. The exploration, projected to cost up to \$2 million annually, would extend through 1980.

Prospective uranium properties in Grand County were leased to the Tennessee Valley Authority. TVA made an initial payment of \$33,000 for leasing rights to the Robert G. Rees lands and would provide additional funds for exploration. If uranium was discovered and produced from the properties, TVA would also pay royalties totaling 10 percent of the value of the ore produced.

Bennett Petroleum Corporation acquired a 240-acre lease on a uranium

Table 2. Summary of production in Utah, 1972-1976.

Year	Crude oil			Natural gas	
	Average daily production (bbls)	Total annual production (bbls)	Value at wellhead	Total annual production (mcf)	Value at wellhead
1972	72,795	26,570,196	\$ 78,276,444	74,178,602	\$6,711,000
1973	89,525	32,676,807	117,742,981	77,011,695	6,887,792
1974	107,884	39,363,032	1	78,403,361	1
1975	109,659	40,025,353	1	76,183,341	1
1976	94,000 ²	35,384,000 ²	1	55,904,000	1

Source: Utah Geological and Mineral Survey data.

¹ Data not available.

² Preliminary.

deposit near Moab, Utah. The company planned to begin core drilling on the property and to go into production within two years.

UOCO of Salt Lake City planned to purchase uranium ore from independent producers with mining operations distant from mills. The uranium-buying program was expected to generate a cash flow for independent miners to develop properties that do not have a market at present.

OIL AND GAS OPERATIONS

The number of active rotary rigs in Utah was steady throughout the year. Deep-test wells, those drilling to depths of 18,000 to 20,000 feet, were widely scattered. Exploratory wells were drilled in several previously unexplored parts of the state. Field development kept at a steady pace.

Drilling efforts were concentrated throughout two geological areas of Utah—in the Overthrust Belt and along the Cordilleran Hingeline. More than half of the seismic crews in the Rocky Mountain region operated within the multi-county vicinity of southwestern Wyoming and northeastern Utah, and considerable seismic work was conducted throughout the general south-central Utah area.

Though oil production was down 5 million barrels to roughly 35,384,000

barrels, compared with over 40 million barrels in 1975, oil was the largest single contributor to mineral values for 1976 (table 2). Production value was \$306,072,000 compared with \$348,131,000 in 1975. Oil production showed daily averages of 94,000 barrels, considerably below the 109,600 barrels-per-day average achieved in 1975. Drastic decreases occurred in the Uinta Basin's Greater Altamont-Bluebell field. In 1975 that area accounted for 22.3 million barrels—almost 58 percent of the Utah total. But current production from the field was running about 46,700 barrels per day, compared with 63,000 barrels per day a year ago. Other production around the state had largely been from older fields where output was also declining. Despite the renewal of field development, which helped to boost production, the Aneth field of San Juan County was producing about 22,400 barrels per day compared with an average of 22,800 barrels per day two years ago. Greater Red Wash field dropped from 10,425 barrels per day to 10,000 barrels per day.

Petroleum Information Corporation reported that oil and gas drilling in the Rocky Mountain States declined by 18 percent from 1975. Drilling in the western states accounted for 3,737 wells, 858 fewer than in 1975. Drilling declined in Colorado and Wyoming, and a big drop of 39 percent was noted in Utah. Only

Table 3. Summary of drilling in Utah, 1972-1976.

Year	Wildcats drilled		Development wells		Service wells	Total wells	Total footage
	Oil/gas	Dry	Oil/gas	Dry			
1972	12	56	76	15	0	159	1,292,374
1973	3	42	130	20	1	196	1,678,359
1974	8	50	130	8	0	196	1,610,343
1975	13	51	121	12	1	198	1,673,018
1976	1	34	67	18	0	120	838,238

Source: Utah Geological and Mineral Survey data.

120 wells were drilled in Utah compared with 198 drilled the year before. Only one small oil discovery was completed compared with six the previous year. Operators drilled 35 exploratory wells out of the total 120 wells completed. Overall drilling included 59 oil wells, 9 gas wells, and 52 dry holes (table 3).

OIL AND GAS EXPLORATION

Exploration throughout the year focused on the Overthrust Belt in north-eastern Utah. Pineview field, about 12 miles east of Coalville, was discovered in 1975 by American Quasar Petroleum, Energetics, and North Central Oil; and by the end of 1975 two wells in the field had produced 225,000 barrels of oil. By the end of April, the field had produced 339,415 barrels of oil, a monthly average just under 25,000 barrels, and 283,361,000 cubic feet of gas. Towards the end of June three wells had been completed and a fourth was near completion. By December the field had six wells producing 3,590 barrels daily. Additional development wells were being drilled in the field, and a well was completed 6½ miles southwest of the field. A 6-inch pipeline from Pineview north to west of Evanston was started by Amoco Production.

Three wells were scheduled to about 8,800 feet in Summit County by Anschutz Oil Corporation. Anschutz's projected 9,700-foot test to the Nugget Sandstone, 8 miles north of Pineview, had been spudded just before the end of the year.

December reports showed that American Quasar Petroleum was drilling three wells in northeastern Utah. At the No. 1 Hoffman, southwest of Randolph, the operator was drilling at 13,000 feet. This well is about 25 miles northwest of Amoco Production's significant Ryckman Creek discovery well northwest of Evanston, Wyoming, and about 55 miles north of Pineview field. Also in Rich County, American Quasar was drilling at an unreported depth at its No. 20-1 Hogback Ridge, 13 miles north of Randolph. And to the southeast near Woodruff, American Quasar was drilling below 9,300 feet at the No. 23-1 Putnam. In Cache County, just out of Logan, Amoco Production was drilling below a depth of 5,000 feet at its No. 1 Reese exploratory well, scheduled to go to at least 9,500 feet.

Colorado Energetics Incorporated and Impel Corporation, both of Denver, scheduled a 16,500-foot test of the Weber Formation (Pennsylvanian) on the Overthrust Belt in Summit County. The deep wildcat, No. 13-3 Weber Coal Company, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 3, T. 2 N., R. 5 E., is 11 miles west of Jurassic oil and gas production in Pineview field and 1 mile northeast of the town of Coalville. The nearest well is $\frac{3}{4}$ mile to the southwest, an 11,434-foot failure. The new test is 2 $\frac{1}{2}$ miles west of a 13,124-foot failure drilled last year by Colorado Energetics and Fuelco which drilled through at least five major thrust faults.

The deepest well in Utah was drilled in Summit County 3 miles east of Bridger Lake field. CIG Exploration abandoned the No. 1 Cook-C, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 17, T. 3 N., R. 15 E., at a total depth of 21,786 feet. It was started by Phillips Petroleum in June 1974. CIG took over operations in October 1975 at a depth of 15,412 feet in the Morrison Formation. Intermediate casing was set to 15,402 feet, and 7-inch casing was set at 21,382 feet. The failure was on the Red Mountain unit, 2 $\frac{1}{2}$ miles northeast of the nearest producer in Bridger Lake field and $\frac{1}{2}$ mile south of the Wyoming state line. Bridger Lake field produces from the Dakota Formation. The field's deepest test bottomed in the Nugget Formation. The state's previous depth record, 20,450 feet was set in 1974 by Phillips Petroleum and Shell Oil at No. 1 United States-E, NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 27, T. 19 S., R. 3 E., on the hingeline in Sanpete County.

Deep drilling, to 15,000 feet and more, decreased considerably, particularly along the lucrative Tertiary trend in the deeper part of the Uinta Basin. A number of operators, including Shell Oil, Chevron Oil, and Gulf Oil, cut back on drilling activity throughout the Altamont-Bluebell area. An increasing number of marginal wells indicated that the boundaries of commercial production on the east, south, and north, had been reached.

A small oil discovery south of the town of Duchesne was completed by Burton-Hawks Company of Casper, Wyoming. The No. 15-1 Wire Fence Canyon well flowed just under 5 barrels of oil and 232,000 cubic feet of gas per day from a depth of 3,969 feet. Additional drilling was under way in the area.

In Uintah County, Houston Oil and Minerals Corporation set casing to 4,032 feet at the No. 12-7 Federal, 10 miles northeast of Roosevelt and about 10 miles north of the West Gusher area. In addition, the company had started completion tests at the No. 11-9 Federal in Kane County 16 miles north of Escalante. The well was at a total depth of 10,285 feet.

During September a \$12 million limited partnership was formed by Belco Petroleum and an undesignated major corporate investor. They will conduct developmental drilling in Utah and exploratory work in other parts of the Rocky Mountain region. The Utah program in the Uinta Basin included drilling in Chapita Wells field, centering in T. 9 S., R. 22 E., Uintah County. Belco was to be the general partner and would contribute \$3 million of the initial capital. The investor would be a limited partner and would contribute \$9 million. Subject to a nonconsent provision, further capital contributions were to be made by the partners for any development work following initial drilling on exploration prospects. Belco was to have a 25 percent interest in the wells drilled in Utah and in the first well drilled on each exploration prospect until recovery of the initial investment. After payout Belco's interest would increase to 55 percent.

Elsewhere in Utah, drilling was widely scattered. Willard Pease Drilling completed its No. 1-32 Kewanee, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 32, T. 19 S., R. 23 E., in Grand County, flowing 9,100,000 cubic feet of gas per day from the Dakota Formation between 2,343 and 2,452 feet. Total depth was 3,131 feet. The well is 1 $\frac{1}{2}$ miles southwest of North Cisco Springs field and a little more than 1 $\frac{1}{2}$ miles northwest of Cisco Springs field. North Cisco Springs field produces from the Dakota Formation, and Cisco Springs field has production from the Morrison Formation.

During September, Willard Pease reported plans for 12 wells to be drilled in eastern Utah. The prospective wells were within 1 mile of Westwater, Cisco Springs, and Salt Wash fields in Grand County and within 1 mile of Cowboy field in San Juan County. The cost of the series was estimated at about \$2 million.

Pease also disclosed a contract to deliver natural gas from 11 wells in Cisco

Springs field, Grand County, to Northwest Pipeline Corporation. Gas was also scheduled to be delivered by Pease from three wells in Lower Horse Draw field in Rio Blanco County, Colorado, to Western Slope Gas. According to Pease the combined interstate delivery from the fields would approximate 10 million cubic feet daily at \$1.50 (\$1.42 plus Btu adjustments) per thousand cubic feet. Willard Pease Oil & Gas maintains offices in Grand Junction, Colorado, and Salt Lake City.

Near the end of 1976, an 18,000-foot test of the Leadville Formation (Mississippian) was scheduled by Mobil Oil for Grand County. The deep test, No. C-1 McCormick-Federal, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 11, T. 21 S., R. 22 E., is in the Cisco area about 28 miles north and a little east of Moab. Nearest production from Mississippian was 35 miles to the west-southwest in Salt Wash field. Closest drilling to Mississippian was a Continental Oil failure in sec. 17, T. 22 S., R. 20 E., 17 miles west-southwest.

In San Juan County, Oil Development of Utah scheduled the No. 1 Pickett Corral-Federal, NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 6, T. 37 S., R. 25 E., a projected 6,100-foot test of the Paradox Formation. The Paradox Basin wildcat is 7 miles north of an oil discovery in the Ismay Formation, completed in 1974 pumping 62 barrels of oil and 195 barrels of water per day. The new venture is 14 miles east of the town of Blanding and 20 miles north of the Aneth area.

Mountain Fuel Supply Company completed a small gas well east of Monticello at the No. 1 Carter Levertton-State, sec. 23, T. 33 S., R. 26 E., San Juan County. It flowed 258,000 cubic feet of gas per day from the Ismay Formation at 5,692 feet. The well was originally abandoned by the old Carter Oil Company in 1958.

Other companies active in San Juan County included Ladd Petroleum, Texaco, Shenandoah Oil, Arapahoe Petroleum, and Superior Oil. Texaco and Superior Oil were carrying on extensive development well work in the Aneth field.

A remote test in Millard County was unsuccessful. Williams Company abandoned the No. 1 Monroe-Fee, SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 14, T. 20 S., R. 2 W. Pipe

was set to 13,501 feet total depth. No other details were released. The Williams Company took over operations from Anschutz Corporation. The failure is about 50 miles west of Ferron field where production is from Ferron Sandstone (Cretaceous) and Kaibab Limestone (Permian). The venture was one of the last wells drilled in a major program of exploration by William Brothers of Tulsa, Anschutz Corporation of Denver, and Broken Hill Proprietary, Limited, an Australian mining, manufacturing, and steel concern. The series involved more than 1.3 million acres in 12 states, including five in the Rocky Mountain region: Wyoming, Montana, Colorado, Utah, and New Mexico. Anschutz was the operator. In a division of the acreage involved in the drilling program, Williams Company acquired about 350,000 acres. The operating company for Broken Hill was Hematite Petroleum.

Hanson Oil rescheduled a third start on its deep Jurassic prospect in Sanpete County, where two attempts failed during the year. The new test was No. 1A-X Moroni, SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 14, T. 15 S., R. 3 E., 1 mile southeast of the town of Moroni. Both previous tests were, like the present one, scheduled to 20,000 feet to test the Navajo Sandstone. The tests are in the Wasatch Plateau-Cordilleran Hingeline area of central Utah, about 20 miles west-southwest of Clear Creek gas field, which produces from the Ferron Formation (Cretaceous). The earlier tests were the No. 1 Moroni, which was drilled to 3,100 feet, and the No. 1-A Moroni, which went to 7,744 feet.

In Juab County, Dixel Resources, Houston, is drilling the No. 1 Gunnison, NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 15, T. 16 S., R. 1 E., at the end of the year. The well is scheduled to Mississippian at a depth of at least 18,000 feet. No previous drilling in the area has reached comparable depth. The Dixel well, about 14 miles southwest of the Hanson Oil deep test, is about 28 miles west of the depleted Joes Valley field and about 30 miles west of abandoned production in Flat Canyon field. The town of Nephi is 20 miles to the north.

The San Rafael Swell area of Emery and Wayne Counties had widely scattered exploration. New drilling was planned in the Price area within 20 miles of Sunny-side.

Oil and Gas Leasing

Lease applications on federal lands in Summit, Morgan, and Cache Counties, in central Utah, and in the southwestern basin and range plateaus of Millard, Sevier, Iron, and Beaver Counties were filed during the year. Leasing was active in the Coalville area north through Randolph and throughout the Bear Lake vicinity. Several sales of oil and gas leases were held during the year by the Division of State Lands of the Utah Department of Natural Resources, the Uintah and Ouray Indian Agency at Fort Duchesne, and the U. S. Bureau of Land Management.

Throughout 1976, oil and gas leasing was adversely affected to a large degree by an announcement by the U. S. Department of the Interior, Bureau of Land Management, in March, which stated that the BLM was considering an increase in rental rates for noncompetitive oil and gas leases and in the filing fee for record title assignments on federal lands. The rental rate would double from 50 cents to \$1.00 per acre, while the fee would increase from \$10 to \$25. The rental for oil and gas leases had been 50 cents an acre since 1960. The proposal, affecting 43 CFR Part 1300, was published in the Federal Register of March 18. Filing fees for record title assignment must be submitted with applications for approval of a lease transfer. This fee is not refundable even though the application may be withdrawn or rejected. The BLM announced on January 8, 1977, that the rate increase would go into effect on February 1, 1977.

In March more than 114,000 federal acres in the Overthrust Belt area of northern Utah were covered in applications. Most of the land was in Rich County. Ed Pendleton, Denver, filed on more than 47,000 acres, and John Phillips Errebo, Jr., Denver, covered another 44,800 acres, both concentrating in Tps. 13-15 N., Rs. 5-6 E. Vern K. Jones, Salt Lake City, filed on more than 22,000 acres in the same area, and Filon Exploration, Denver, added another 12,500 acres nearby. Neva Henderson, Roy E. Barnes, Kent E. Peterson, and Patricia Hickok, all of Salt Lake City, filed on smaller areas of land in Rich and Cache Counties, with no particular concentration of acreage apparent.

In November, new oil and gas lease applications in western Utah were filed

with the BLM. Oil and gas lease applications were filed on more than 834,380 acres during one week, primarily in the area west of Milford and reaching far north-northwest past the Goshute Indian Reservation in the vicinity of Ibapah in southwestern Tooele County. The largest of those filings was by R. C. Hoefle of Billings. His applications covered 210,100 acres southwest of Sevier Lake spreading through the Wah Wah Mountains and vicinity, about 15 miles west of Milford, and throughout seven townships south of Garrison, along the Utah-Nevada state line. Some 58,000 acres were filed by Trend Resources, Ltd., Denver, in the Ibapah area north of the Goshute Indian reservation and north of Garrison along the state line. Earl Cranston, Billings, filed on 124,375 acres southeast of the reservation in the Trout Creek area. Others active in oil and gas leases included Dave Reed, Dallas, who filed on 58,250 acres in the White Valley region between the Confusion and House Ranges about 40 miles west of Delta; Esdras Hartley, Denver; Wilfred Gray, Denver; D. R. Gaither, Salt Lake City; Emerald Oil, Salt Lake City; Robert Healy, Salt Lake City; and William Stevenson, Salt Lake City.

W. A. Johnson of Englewood, Colorado, filed lease applications covering more than 173,000 acres in Kane County. They covered 30 miles reaching south of Bryce Canyon National Park throughout the White Cliffs region northeast of Kanab.

In Cache County, Dean Rowell, Salt Lake City, filed leases in seven townships in a north-south direction in the Bear River Range east of Logan. He also filed on more than 85,000 acres in the western part of Sevier, Sanpete, and Piute Counties. Some 52,000 acres were filed on by Rowell in the Cove Fort vicinity of Millard County.

During November oil and gas leasing covered over 1,400,000 acres scattered largely through the western-half of Utah. An oil discovery by Northwest Exploration Company at their No. 1 Trap Springs south of Ely, Nevada, in the Eagle Springs area, stimulated the leasing activity in Utah. Northwest Exploration recovered oil on tests between 4,200 and 4,800 feet at the well. Delbert Grote, Denver, immediately filed oil and gas leases on 134,273 acres of federal land in Millard and Beaver Counties. Jerry Hill, Denver, also filed applications on

203,000 acres about 30 miles west of Milford.

In early December another 360,000 acres were covered with oil and gas leases, which brought the total to nearly 2 million acres of Utah lands subject to leasing. Of the 360,000 acres, 249,626 acres were in western Utah's Beaver, Millard, Juab, and southwestern Tooele Counties.

Lease applications were filed by W. A. Johnson of Englewood, Colorado, on more than 71,000 acres; Margaret Coombs, Salt Lake City, on 30,100 acres; and William Schick Tanz, Denver, on over 17,000 acres. Many other applicants included Wallace & Brownlee, Denver; Mobil Oil, Cities Service Oil, Amoco Production, Delbert Grote, and Jerry Hill of Denver.

After six consecutive weeks of oil and gas leasing on more than 200,000 acres each week, Utah's oil and gas lease applications on federal land dropped to 53,000 acres during the last week of December. Lease applications on federal lands during the last week were primarily filed by two Salt Lake City independents, S. McCormick and Crest Resources whose applications covered slightly more than 27,000 acres southwest of Escalante. J. Tully, Denver, filed on 4,400 acres in the Vernal area. The remainder were those applications of a few independent lease brokers in Salt Lake City and Denver.

Oil and Gas Lease Sales

Light bidding at a Utah Department of Natural Resources, Division of State Lands, lease sale in February resulted in 13 of the 30 tracts offered being sold. High bid was \$2.57 an acre, paid by Harry Ptasynski, on a 520 acre parcel in sec. 16, T. 40 S., R. 23 E., less than 1 mile north of Recapture Creek field in San Juan County. Bidding averaged \$1.49 an acre, and a total of 4,942.55 acres were sold for \$7,398.94. The offering included 14,041.35 acres for oil and gas leasing.

The Utah Department of Natural Resources, Division of State Lands, sold 18 of the 33 tracts offered for oil and gas and hydrocarbon leasing at a sealed bid sale in June. High bid was \$15.57 an acre, paid by Sheridan L. McGarry, for a 560 acre parcel in sec. 16, T. 15 S., R. 23 E., Uintah County. The high bid parcel is

about 4 miles northeast of Fence Canyon field and 6 miles northwest of East Canyon field. A. N. Henderson paid \$15.50 an acre for a parcel in secs. 29 and 32, T. 7 S., R. 21 E., Uintah County. Raymond Chorney was the most active bidder, taking seven parcels. Bids averaged \$4.09 an acre. A total of 8,351.01 acres of oil and gas leases were sold for \$34,229.61. The offering included leases in Uintah, Emery, Grand, San Juan, Wayne, Garfield, and Kane Counties.

Skyline Oil paid \$53.15 per acre for 352.76 acres in Salt Wash field and was high bidder at the oil and gas lease sale held by the Utah Department of Natural Resources, Division of State Lands, in July. The high bid parcel was in sec. 16, T. 23 S., R. 17 E., Grand County. The 142 tracts, totaling 82,746.42 acres, were offered for oil and gas and hydrocarbon leasing.

Gulf Oil paid \$6.85 an acre for a parcel in Monument Butte field in Duchesne County, and it was high bidder at the Bureau of Land Management oil and gas lease sale held in Salt Lake City in June. Gulf's bid, totaling \$274, was for Parcel No. 1, 40 acres in sec. 4, T. 9 S., R. 16 E. The bureau offered two parcels containing 400 acres within the known geologic structures of Monument Butte field and an undefined field, both in Duchesne County. The two parcels sold for a total bonus of \$2,290, averaging \$5.72 per acre. Pacific Transmission Supply paid \$5.60 per acre for Parcel No. 2, containing 360 acres in secs. 17-20, T. 9 S., R. 16 E.

Burton-Hawks Company of Casper, Wyoming, paid \$506 per acre for a 400 acre tract in Duchesne County at the Uintah and Ouray Agency oil and gas lease sale in April at the Ute Tribal Community Building, Fort Duchesne. Burton-Hawks' Tract No. 2 was in sec. 26, T. 3 S., R. 6 W., on the south side of the Greater Altamont-Bluebell field complex in the Cedar Rim area. Acceptable bids were received on 42 of the 43 tracts offered. A total of 22,943.33 acres were offered, all in Duchesne County. Total bonus was \$945,215.90 for an average bid per acre of \$42.37.

The Uintah and Ouray Agency held an oil and gas lease sale at Fort Duchesne in August which drew high bonus bids

totaling \$532,424 for 118 tracts containing 41,952.46 acres. Top bid was \$19.77 per acre by Oil Development Company of Utah for Tract No. 49, 639.20 acres in sec. 4, T. 4 S., R. 5 W., in Starvation field. The field produces oil and gas from the Green River and Wasatch Formations. The high bid tract was just north of depleted Wasatch Formation oil and gas production in Indian Ridge field. A total of 139 tracts containing 46,358.29 acres was offered. The Uinta Basin lands, all in Duchesne County, attracted an average bid per acre of \$12.69. Gulf Oil and Koch Industries dominated the sale, taking 64 and 51 tracts, respectively. Gulf's successful bids all went for tribal lands, where the average bid per acre was \$12.94. Koch took 10 tracts on tribal lands and successfully bid on all allotted lands sold with an average bid per acre of \$10.12. The remaining three tracts of tribal lands were taken by Oil Development Company of Utah.

Oil and Gas Production⁷

Monthly oil production for October was 2,841,404 barrels, a drop from the monthly average of 3,171,000 barrels recorded in the first six months of the year. At the end of October, oil production was 28,723,070 barrels. Natural gas production stayed fairly consistent at an average of 6,286,201,000 cubic feet monthly.

Oil Shale and Oil Sand

Utah's oil shale resource is the second most significant deposit in the west, exceeded only by Colorado. An estimated 750,000 acres of eastern Uintah County is underlain by thick, rich oil shale containing between 90 and 115 billion barrels of oil (as kerogen).

At the request of the operators of the two Federal oil shale tracts, Ua and Ub, the U. S. Department of the Interior granted a one-year suspension of operations in the area, commencing in October. The suspension came in response to difficulties in environmental planning. Studies by the U. S. Department of the Interior showed that for intermittent periods natural background level of certain air pollutants exceeded federal clean air

⁷ Source: Division of Oil, Gas & Mining, Department of Natural Resources, *Monthly Oil and Gas Production Report*, October 1976.

standards. During the suspension, the leaseholders are required to maintain environmental monitoring.

The White River Shale Oil Project on tracts Ua and Ub in eastern Uintah County was originally planned to produce 50,000 barrels per day by 1980. The consortium includes Phillips Petroleum, Sun Oil, and Sohio Petroleum. At this time, leases have been acquired, water rights are applied for, and the design for the plant and mine is being prepared.

The Oil Shale Corporation (TOSCO) Sand Wash Project includes five tracts west of the Ua and Ub area. Its estimated output by 1985 is to be 75,000 barrels per day. The operator leased 14,700 acres from the state and was conducting environmental planning programs.

An *in situ* experiment by Geokinetics, Inc., was conducted on State lands in the southern Uinta Basin. Oil shale at shallow depth, which had been "fluffed up" by charges of light explosives, was ignited and burned in place. Encouraging quantities of oil were produced from the small burned areas through very shallow wells.

The WESTCO *in situ* recovery experiment included a 120-acre state lease and was designed to recover oil from oil shale fragments within an underground mine excavated by conventional methods. The consortium was made up of Ashland Oil Company, Standard Oil of California, Cities Service Oil, Getty Oil, Gulf Oil, Mobil Oil, Sun Oil, and Standard Oil of Indiana. Planning and design operations continued.

Utah tar sands (oil sand) operations included the Arizona Fuels Corporation experimental extraction plant and surface mine at southeast Asphalt Ridge located on leases controlled by Sohio Petroleum. Burmah Oil and its successor Aminoil USA, Inc., took over operations in midyear and successfully operated a redesigned plant for short periods before shutting down for cold weather. Operations are scheduled to resume in 1977.

In addition, the U. S. Bureau of Mines conducted *in situ* extraction experiments at its northwest Asphalt Ridge site. Work on the experimental, reverse combustion fireflood, begun in 1975, continued and was scheduled to expand to a greater area in 1977. The experiments are being conducted on leases contributed to the project by Sohio Petroleum.

LEGISLATURE ACTS

(continued from page 1)

tion includes the hiring of a state paleontologist in the division on state history.

With a weather eye on the skies and the worsening drought, the legislators shelved several proposals to buy tracts of land for parks around Great Salt Lake and to improve existing park facilities along the south shore of the lake. The money not appropriated for these purposes will be earmarked instead as contingency funds for the emergencies expected to arise as the drought becomes more critical.

LATEST STUDIES

(continued from page 2)

Dellwig, and Thomas Schmutge (\$1.00). Reprinted from *Radio Science*, Vol. 10, No. 11, November 1975.

UGMS has its unpublished Reports of Investigation on open-file. These recent reports may be examined at the UGMS offices:

Report of Investigation No. 114, *Reanalysis of UGMS Quarterly Brine Samples by Great Salt Lake Minerals and Chemicals Corporation*, by J. Wallace Gwynn, March 1977, 2 p.

Report of Investigation No. 115, *A Preliminary Investigation into the Electrochemical Potential of the Great Salt Lake, Utah*, by J. Wallace Gwynn, March 1977, 7 p.

Hazards Meeting Well Attended

The Second Governor's Conference on Geologic Hazards held on March 7 at the Salt Lake Hilton was attended by about 160 registrants who heard a full day of formal and informal presentations on almost every aspect of geologic hazards. Nineteen speakers covered a variety of topics in four separate sessions: introductory; legal, regulatory, and political; technical; and consumer viewpoints.

The introductory session was succinct with a brief introduction by meeting chairman, Graham Campbell; a definition of geologic hazards by conference chairman, Bruce Kaliser; and a summary of the current situation by Governor Scott Matheson.

The second session—legal, regulatory, and political—featured talks, one by a legislator and the rest by officials from county and state agencies. Representative Genevieve Atwood summarized legislative action under way and proposed in the legislature up to that time. The other papers emphasized planning, zoning, building inspection, response to emergencies, and public health.

Session three—technical—featured talks on structural and architectural standards and practices and strong motion instrumentation and a summary of the activities of the Utah Geological

and Mineral Survey in earthquake hazard reduction.

The last session featured talks that touched on such varied subjects as disclosure of information in land sales, insurance, tax assessments, mortgage loans, consumer problems, and legal ramifications at the state and local level. Possibly the most dramatic presentation was by Ed Yeates of KSL who showed a video tape of the locally popular TV news documentary, "Cliff Dwellers."

The noon luncheon featured an exceptionally well-illustrated lecture by Dr. Laurence H. Lattman, Dean of the College of Mines and Mineral Industries at the University of Utah. The large luncheon audience was taken on a wide-ranging exhibition of the Earth as it is viewed from outer space in satellite photography and imagery.

The First Governor's Conference on Geologic Hazards was held in 1967. In concluding his summary of the current situation at the second conference, Governor Matheson expressed his hope that another conference might not be necessary ten years hence, or that if one were held, it would feature progress reports rather than continue to call for action.

Geographers and Lake Specialists Convene

Two meetings of great interest to geographers and geologists were held in Salt Lake City and Ogden in late April and early May. The national meeting of the Association of American Geographers, held in Salt Lake City at the Hotel Utah, April 24-27, was attended by more than 2,000 persons from all parts of North America and by several hundred overseas visitors. Geologists from the Utah Geological and Mineral Survey assisted their geographer colleagues as field-trip guides on the weekend prior to the meeting. Bruce Kaliser, chief of UGMS' Urban and Engineering Geology section, toured with the AAG group viewing environmental hazards and urban development along the Wasatch Front. Howard Ritzma, UGMS assistant director, assisted as guide for the two-day trip to the Uinta Basin where the AAG group viewed oil fields and tar sand deposits and took side trips to the area's dinosaur localities and spectacular geologic and geomorphologic exposures. During the meeting Carlton Stowe of UGMS displayed maps and materials on the natural resources, mineral activities, and coal fields in Utah.

The International Conference on Desertic Terminal Lakes, sponsored by Weber State College, the National

Oceanic and Atmospheric Administration, the Utah Water Research Laboratory (Logan), and several divisions of the Utah Department of Natural Resources, was held May 2-5 at Weber State in Ogden. During the four days of sessions more than 40 papers were presented on various aspects of terminal lakes such as climatology, exploitation of saline mineral resources, geochemistry, and biology.

In addition to emphasis on the Great Salt Lake of Utah and other lakes of the Great Basin region in the western U. S., papers were presented on terminal lakes in Israel (Dead Sea), Soviet Union, India, Africa (Lake Chad), Iran, Australia, and Antarctica. Speakers and other registrants came from many parts of the U. S., from Canada, and from 10 other countries including USSR, Israel, French Guiana, India, Australia, and Kenya.

Five field trips were held during the conference to view the Great Salt Lake and the salt industries around the lake. Several trips were organized and conducted by Dr. J. Wallace Gwynn, chief of the UGMS research section. Proceedings of the conference will be published and will be available from Weber State College.

law. The slide, a "classic" as described by engineering geologists and soils engineers, has all but destroyed the northeast corner of the foundation for the \$1.5 million Ensign School under construction in the city's upper avenues section between 11th and 13th Avenues at L Street.

The slide area is one in which there has been major reshaping of terrain in the past two years. Old gravel pits and spoil banks at the mouth of Valley View Canyon have been leveled and graded to provide the ground for the school site and an adjacent park that also contains a retention basin for spillover flood waters of the canyon.

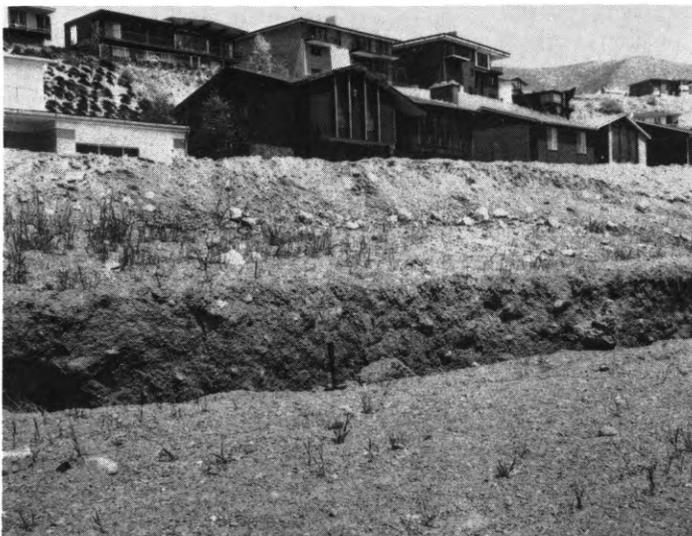
During the summer of 1976 two thunderstorms hit the area and dumped enough rain on the uncompleted project at the canyon mouth to wash tons of mud, silt, sand, and boulders down the steep streets for a mile or more to South Temple and First South Streets. Hasty stabilization work and vegetation planting was undertaken by city crews assisted by environmental technicians from Kennecott Copper. The remaining dry summer and autumn had one beneficial effect; no new storms disturbed the stabilized site.

The landslide that developed in April appears to have little relation to the flood problem but may be significantly connected to the reshaping of the terrain of the area. It was first noted on Friday, April 8, by Mr. Vernon Forbush, superintendent for Tingey Construction Company, general contractors for the school construction. He was annoyed to *(continued on page 15)*

Landslide Halts School Construction

As if to emphasize the importance of newly enacted House Bill No. 48 making site review of critical public

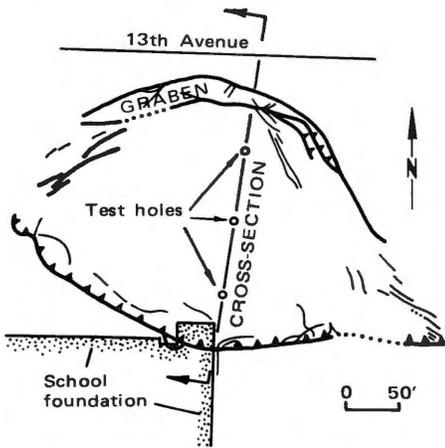
facilities a UGMS responsibility, a landslide at a Salt Lake City school site was reported shortly after the bill became



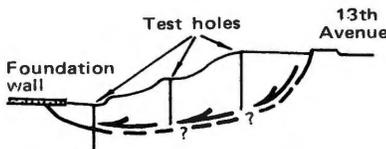
Above left: Head scarp of slide about 25 feet south of 13th Avenue. Homes in background are on north side of street and on higher streets of upper avenues. *Above right:* Well-defined graben immediately south of head scarp of slide (left). Scarp is about 2.5 feet high.

LANDSLIDE

(continued from page 14)



Map of slide showing head scarp along 13th Avenue and "overthrust" along sole of slide to south.

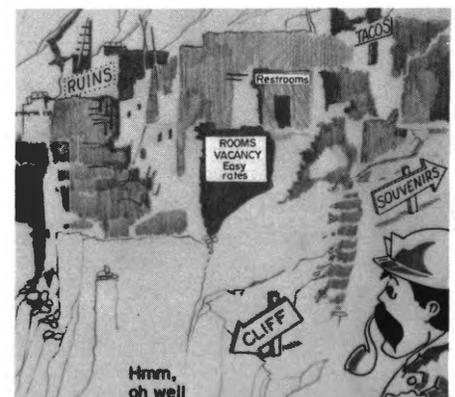


South-north cross section through slide showing direction of movement. Test hole closest to foundation cut sole of slide and has been displaced.

find the northeast corner of the foundation one inch too high and directed that the height be chiseled off before brick-laying began. By Monday, April 11, ground cracks were noted, and in a few more days it was apparent that the ground beneath the northeast corner of the foundation was rising. By the 15th the rise was 7 inches, by the 26th 14½ inches, and by May 9 it was 17 inches. Meanwhile, parts of the northeast foundation walls had been pushed south as much as 10 inches.

(continued on page 16)

ROCKY RIDGES



UTAH GAS RESERVES DOWN

Utah's natural gas reserves declined sharply from 1975 to 1976 according to the annual survey of the American Gas Association. Gas reserves in the Rocky Mountain region showed a modest increase, but U. S. reserves declined about 5 percent. The decline has been noted for the last six years and brings the nation's reserve to its lowest level since 1954.

Reserves for Rocky Mountain states were estimated as follows:

State	Reserve 12/31/75 (billion cubic feet)	Reserve 12/31/76 (billion cubic feet)	1976 reserve as percentage of 1975
Colorado	1,893	1,888	99.7
Montana	930	1,106	118.9
Nebraska	56	59	105.3
New Mexico (northwest)	7,788	7,995	102.6
North Dakota	417	406	97.4
Utah	917	830	90.5
Wyoming	3,703	3,704	100.0
Totals	15,704	15,988	101.8

Texas and Louisiana at the end of 1976 had 122,152 billion cubic feet of gas in reserve, or 56.5 percent of the nation's total. Alaska ranks third with 31,929 billion cubic feet, or 14.8 percent of the U. S. total. Utah's reserve is slightly less than 0.4 percent of the nation's total of 216,026 billion cubic feet. The Rocky Mountain region, including Arizona and South Dakota, contains about 7.4 percent of the nation's reserve of natural gas.

LIEU LANDS EXCHANGE

The exchange of "in lieu" lands between the federal government and the State of Utah has slowed to a near standstill. Acreage exchanged to satisfy Utah's entitlement to school lands not received at statehood has been as follows:

Prior to 1960—32,440 acres;
1961-1965—246,270 acres;

1966-1970—84,650 acres; and
1971-1975—16,273 acres.

Only 20 acres were exchanged in 1974, 80 in 1975, and none in 1976. Utah's remaining entitlement on September 30, 1976, was 225,360.59 acres. About 157,000 acres of oil shale land in eastern Uintah County has been selected by the State and is involved in litigation.

by Greg McLaughlin

LANDSLIDE

(continued from page 15)



Above left: Closeup of sole of slide displaying overthrust relation. Note displacement of bulldozer tracks (arrow). Above right: Foundation wall raised and bowed to south (right).

UGMS personnel were first notified of the moving ground on April 25. By this time, a well-defined slide was apparent in the embankment north of the

school site with the head scarp (break-away point) just 25 feet south of 13th Avenue. The slide plane is steep at the crown, shallowing to the south in the direction of movement and then rising to the surface with reverse dip in the typical concave shape of these movements. It has apparently developed in the poorly sorted, red clay, silt, and gravel deposits of Lake Bonneville that overlie the Eocene Wasatch (or Knight) Formation. The toe or broad front of the slide has pushed the ground ahead of it forward and upward in "classic" overthrust fashion. The slide is 400 feet wide and 250 feet from crown to toe. Construction has been halted while the project engineers, Rollins, Brown, and Gunnell of Provo, undertake tests and consider remedial action.

movement just after a very wet March in which precipitation was 190 percent of normal in Salt Lake City. This landslide emphasizes the hazards and the great potential economic loss that can happen from building major structures in locations prone to slope failure, particularly when the terrain has been disturbed and modified by a major grading operator



Toe of slide showing overthrust (shadowed area in center). Ensign School foundation in background. Hammer handle is 11 inches long.

Although occurring in a period of extreme dryness, the landslide did begin

UTAH GEOLOGICAL AND MINERAL SURVEY
SURVEY NOTES

State of Utah *Scott M. Matheson*
Governor

Department of Natural Resources *Gordon E. Harmston*
Executive Director

Utah Geological and Mineral Survey *Donald T. McMillan*
Director

Editorial Advisor *Howard R. Ritzma*
Editor *Roger C. Stewart*

State of Utah—Department of Natural Resources
UTAH GEOLOGICAL AND MINERAL SURVEY
606 Black Hawk Way
Salt Lake City, Utah 84108

Address Correction Requested

Nonprofit Org.
U. S. Postage Paid
Permit No. 1529
Salt Lake City, Utah