UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

QUARTERLY REVIEW

Vol. 4, No. 2 | *Geologic Investigation in the State of Utah* | May 1970

MHD OFFERS SOLUTION

A power production technique capable of overcoming some of the difficulties associated with techniques now in use is being aired.

The development of magnetohydrodynamics, or MHD, as part of an overall coal research program, was discussed in a public hearing on Emerging Power Techniques held in December by Sen. Frank Moss (D-Utah), chairman of the Senate Subcommittee for Minerals, Materials and Fuels of the Committee on Interior and Insular Affairs.

In a statement before the subcommittee by Arthur A. Kantrowitz, director of Avco Everett Research Laboratory and vice president of Avco Corporation, the five principal advantages of MHD over coal-fired or nuclear power plants were outlined:

1. Drastically reduce thermal and atmospheric pollution.
2. Better use our coal reserves and other natural resources, especially low-grade coal.
3. Open opportunities for the development of water-scarce areas.
4. Improve the efficiency and reliability of our electric power systems.
5. Provide low cost power.

Kantrowitz summarized the power systems in his testimony.

Conventional steam-electric power generation produces electric energy in three steps:

1. Fuel and air are burned together in a furnace.
2. The resulting heat makes steam in a boiler; the steam is expanded in a turbine to produce mechanical power.
3. The turbine shaft drives the elec-

(Continued on page 3)

Field Day for Real Estate Examiners

The Utah State Board of Real Estate Examiners were conducted on a field excursion to examine results of poor planning and geologic ignorance. Bruce Kaliser, UGMS engineering geologist, oriented the Board in the State Division of Real Estate offices and then accompanied them to inspect a particularly afflicted subdivision that he has been monitoring over the past two years. The subdivision is composed of homes worth upwards of $25,000 each and is experiencing severe problems with expansive clay, reactivated landsliding, ground frost and impermeable septic tank filter field soils.

Snow covering on the ground offered protection from the highly plastic clay that normally quickly overtops one's boots and weighs one down with the ever-accumulating clods. Despite the weather the group was able to see clearly the magnitude of the problems.

Examination of house heavily distressed by renewed landslide activity. Not cracks in mortar, and the ancient landslide terrain in background.

UGMS has installed a strain gauge (extensometer) across a hairline tension crack in the landslide. The photograph below shows the tilt of a utility pole situated in the same tension crack. The relief on the ancient landslide in the background of the photograph makes it extremely attractive as an area in which to expand the subdivision. New communities serving as dormitory towns for the Wasatch Front are likely to enlarge considerably.

The Board is to be commended for its forthright approach to this demonstration of the result of lack of planning and UGMS hopes that further cooperation will minimize the Topsy-like growth which proves to be so disastrous.

Left to right: Jesse M. Payne, State Dept. of Contractors; Marion Wallace and Glen Baugh, Board of Real Estate Examiners; Monroe Tucker, Director of the State Division of Real Estate, all standing on the head of the slide. Standing on the crown of the landslide are, left to right, Edwin Stein, Chairman of the Board of Real Estate Examiners, and Ray Hansen, State Dept. of Contractors.

GROUNDWATER DETERIORATING

The chemical quality of the groundwater in large areas in Utah is deteriorating, according to U. S. Geological Survey Professional Paper 650-D. The study, by Hardy, Mower and Sandberg, was issued from the Salt Lake office of USGS in 1969.

Most of the records of rainfall, well level and specific conductance of well water cited in the report go back to 1957, some to 1931. Three areas in south central and southwest Utah were under study: Pavant Valley, Sevier Desert and Escalante Valley.

Changes in the chemical character of the groundwater result mainly from dissolved materials in the irrigation water which recharges the aquifers. Crop-plant debris and fertilizers dissolved in substantial amounts increase chemical concentrations. In fact, water entering the Sevier Desert in the Sevier River has been reused several times in upstream irrigation operations. Each time a part of the diverted water returns to the river, with an ever-increasing load of chemicals, both from the irrigation operation and from leaching the soil through which it travels.

Another factor in deteriorating water quality is the decline in water levels in pumping operations. As the well level declines, groundwater of poor quality is drawn into it, causing further deterioration. Water from several wells in the Kanosh district in the Pavant Valley is reported to be unusable for irrigation as a result of recirculation of irrigation water.

The quality of groundwater in these districts will continue to deteriorate, according to the USGS hydrologists, as long as present irrigation practices continue to prevail.

Uinta Basin, Southern Utah Record Oil Discoveries

In the closing months of 1969, Utah scored two new oil field discoveries, both in Duchesne County and both considered significant indicators of possible new prolific oil production in the sparsely drilled western Uinta Basin.

The largest discovery, Mountain Fuel Supply No. 2 Cedar Rim, SW NE 20-3S-6W, completed flowing 888 barrels of oil per day from an upper Wasatch (Eocene) sandstone at 8580 to 8670 feet. In February Mountain Fuel also established flowing oil production in this well from 7794 to 7828 and 8095 to 8211 in the lower Green River Formation (Eocene). Production from these Green River zones averaged 1142 barrels of oil per day with 1.212 million cubic feet of gas per day. At least three other zones in the Green River Formation indicated possible oil production on tests during the drilling of the well.

The other Duchesne County discovery was Gulf Oil No. 1 Ute Tribal–Cottonwood Wash, SE NW 7-1N-3W, in basal Tertiary sandstones, probably lower Green River, from 9894 to 9904. The discovery, located in the structurally complex area along the south flank of the Uinta Mountains, flowed 195 barrels of oil per day.

Mountain Fuel has stepped out 4½ miles west of its discovery and is drilling a 9000-foot Wasatch test in the Sink Draw area. No plans for extension of the Gulf discovery have been announced.

The Utah Oil and Gas Conservation Commission has officially named the two discoveries Cedar Rim and Cottonwood Wash fields.

In the first quarter of 1970, interest in the western Uinta Basin heightened as reports from Shell Oil No. 1 Miles, SW NE 35-1S-4W, Duchesne County, suggested a possible oil discovery in Green River and Wasatch sandstones. The Shell well, located 10 miles south of the Gulf discovery and 18 miles northeast of Mountain Fuel's new production, is in the middle of a large untested part of the basin.

Late 1969 and 1970 also saw active development drilling and new production in the Duchesne and Bluebell fields in Duchesne County. Bluebell, where oil production began in late 1967, had produced more than 2,100,000 barrels of oil from 18 wells by the end of March 1970, and production was averaging 3,500 barrels per day. Upon application of Chevron Oil, principal field operator, the Utah Oil and Gas Conservation Commission established 640-acre spacing for oil wells at Bluebell. This is the widest spacing for oil in any Rocky Mountain region field.

In southern Utah early 1970 saw announcement of the second oil field in the Kaiparowits Basin, Garfield County. Tenneco Oil indicated that its No. 1 Johns Valley-Federal SE NW 35-35S-2W was completed as an oil well from Mississippian limestone at 11,029 to 11,040 feet. Production rates were not revealed, and additional possible production from shallower depths are being tested. Johns Valley Field follows Upper Valley where Kaibab (Permian) production began in 1964.

In southeast Utah's Paradox Basin, Buttes Gas and Oil completed No. 1-22 Federal in NE NW 22-37S-23E, San Juan County, as a new field discovery one mile southwest of the one-well Alkali Canyon Field now shut in. Flowing production of 41 barrels of oil per day was removed from Desert Creek (Pennsylvanian) at 6390 to 6408 feet.

Utah Industrial Minerals Map Released by UGMS

A new map of the industrial minerals of Utah has been recently released by the Utah Geological and Mineralogical Survey. Prepared by Hellmut H. Doelling, economic geologist of the Survey, the map shows where industrial minerals may be found in the state, whether the sites are developed or not and whether actively producing.

Map 29, printed in color, is 11 by 16 inches with descriptive summaries of each locality printed on the back. Copies may be obtained at 103 Utah Geological Survey, Univ. of Utah, Salt Lake City 84112, for 35 ¢, or 50 ¢ prepaid. Mail orders should include the price of the map with the order.

MHD OFFERS SOLUTION

(Continued from page 1)

tric generator which delivers power to the load.

In the generator, the electric power is produced by motion of a copper wire armature through a magnetic field. In the nuclear plant, the reactor replaces the furnace-boiler; otherwise the plant resembles a conventional coal-fired plant.

Technical and economic factors in this three-step process limit efficiency in the coal-fired unit to about 40 percent, and in the nuclear plants to about 30 percent. All the fuel energy not converted into electric power is delivered to the surroundings in the form of heat, usually into rivers, lakes and cooling towers. The pressure of this heat rejection is already taxing the water-rich areas of the country; in water-poor areas, the heat rejection limits development, particularly in the fuel-rich but water-poor western states.

MHD combines all the steps into one. The hot combution products of fuel and air are made to conduct electricity by addition of small amounts of a salt. These gases become the "armature" of the generator; they move at high velocity through the magnetic field where electric power is generated directly.

This direct process eliminates the factors limiting the efficiency of the conventional system. Efficiencies of nearly 60 percent will result, and correspondingly less heat need be absorbed by the surrroundings. MHD plants can in fact be designed to eliminate all thermal water pollution, according to Kantrowitz.

Sulfur dioxide and oxides of nitrogen, the most objectionable gaseous emissions from thermal power plants, will inevitably increase with increasing demands for electric power, and solutions to the problem advanced thus far have many undersirable side side effects. In the MHD plant, combustion occurs in such a way that these noxious gases can be virtually eliminated while delivering useful byproducts for manufacture of fertilizer.

Important national MHD programs are underway in West Germany, the Soviet Union and Japan.

Joseph P. Brennan, director of the Research and Marketing department, United Mine Workers of America, made it clear in his testimony that allocation of Federal research and development money, with $200 million per year for atomic energy funding and $20 million for coal research, displays "a myopia of vision and a misapplication of resources," and that intensive coal research would lead to the most workable solution to our power problems.

Brennan stated there are more than 1 trillion tons of recoverable coal reserves in this country and that most of it is located west of the Mississippi River.

RESOURCES GOALS FRAMED

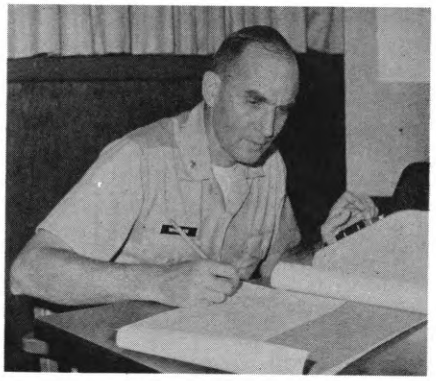
Natural resource goals and implementation are the concern of a committee of the Utah Legislative Council with the impressive title of Citizens' Planning and Organization Committee on Natural Resources.

Meeting weekly, the 12-member group has framed goals relating to recreation, land, water, minerals and air, and are exploring specific ways of attainment. The report which will result is designed to provide future legislators with a framework of recommendations to guide Utah's natural resource management.

The committee is composed of private citizens concerned with natural resources, two members of the legislature and several educators with specialties in natural resource matters. Chairmanship of the group has passed from Fred Montmorency, former mayor of South Ogden, to Merrill Ridd of the Geography Department at the University of Utah. William P. Hewitt, director, and Howard Ritzma, petroleum geologist both of the Utah Geological and Mineralogical Survey, are active members of the committee in mineral-related matters.

UGMS Staff Member on Leave

Even though J. A. Whelan, UGMS geologist is on leave for a tour of duty in the U. S. Navy on Guam, with the rank of commander, he spends some of his spare time working on research being conducted on the Great Salt Lake. Whelan is Deputy Officer in charge of Construction for the Navy on Guam, and started a two-year tour in July, 1969.



Shortly after he left for Guam, Cdr. Whelan's paper, Special Studies 30 in the UGMS series, *Soluble Salts and Subsurface Brines of Sevier Lake, Utah,* was published, and another, of which he is co-author, *Mineralization in the Gold Hill Mining District, Tooele County, Utah,* appeared recently. The latter paper, Bulletin 83, was originally a PhD dissertation written by M. H. El-Shatoury. Whelan supervised his research and assisted in preparation of the manuscript for publication.

A third paper, in press, *Radioactive and Isotopic Age determinations of Utah Rocks,* is a compilation of the results of work done by Whelan and other workers on isotopic age dating.

In March, Whelan presented a paper on his research activities to a joint meeting on Guam of the Society of American Military Engineers and Guam Professional Engineers Society.

When the research in Whelan's charge is completed, the study will provide definite information on the effect of the railroad causeway on brine concentrations and on the potential of the lake as a commercail mineral source. The lake has long been a source of common salt, but there is greater value in lithium, magnesium, potassium salts and sodium sulfate. Estimates indicate there are about $20 billion worth of recoverable chemicals in Great Salt Lake.

Geologic Hazard Study Prevents Goof

by Bruce N. Kaliser
UGMS Engineering Geologist

Geologic investigation of a major potential geologic hazard has undoubtedly prevented one big engineering headache, according to Bruce Kaliser, UGMS engineering geologist.

In the landslide-prone benchland bordering Utah's megalopolis (Provo-Salt Lake City-Ogden-Brigham City), an ancient landslide covers an area of approximately one fifth of a square mile and encompasses a site on which in 1969 the property holder planned to develop an apartment house complex.

Downcutting by the major drainage course has caused sliding of the interbedded deltaic clays, silts and sands since Pleistocene time. Conditions are aggravated by surface and subsurface drainage. The active Wasatch fault zone exists no more than half a mile to the east.

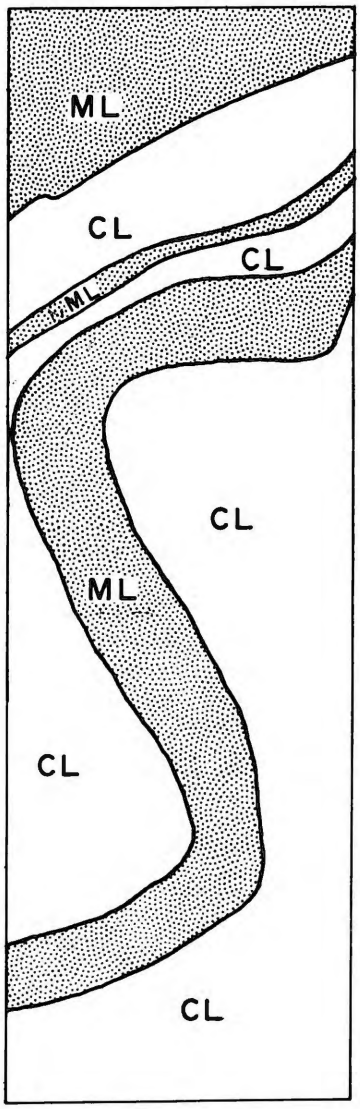
The real estate and development company holding this property engaged the services of an engineering geologist and a soils engineer.

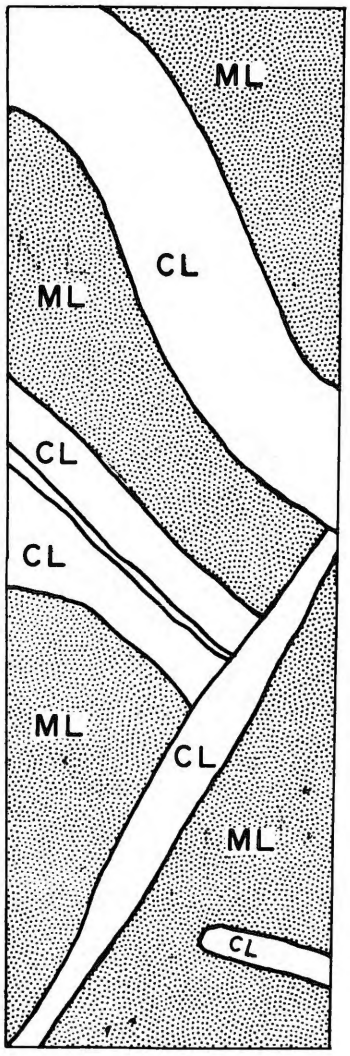
Geologic reconnaissance showed that history, indeed prehistory, has repeated itself. The road and the irrigation canal across the end of the foot of the slide have been affected on more than one occasion. Groundwater in deeper interbedded sands is under artesian pressure. Test borings in and above the site show the entire site to be underlain with distorted and sheared sediments. The sediments were originally laid down on nearly horizontal planes in ancestral Lake Bonneville. Extensive deformation as revealed in undisturbed samples taken in the test borings and bulldozer cuts clearly demonstrate ancient, relatively deep-seated landsliding.

The amenities offered by this property include its proximity to a large city and to a military reservation, its natural serenity and the attractive views of the Great Salt Lake Valley. A clubhouse already occupies a site at its lower end. A municipal golf course lies across the road on the valley flood plain.

The real estate and development company holding this property apparently is the first in Utah to use the engineering and geological information and personnel available in the state. With a knowledge of the conditions on the site at hand, the company then understood the magnitude of the problems. Stabilization would be the first requirement on this site, and development of the site revolves around the means of accomplishing this. In this instance the economics of ensuring against further earth movement led to a decision by the company to eliminate consideration of the site for multistory dwellings.

Responsible planning that takes into full account the geologic aspects of a site is one of the goals of UGMS. Much effort and expense may be avoided by incorporating specific geologic information into the early stages of planning and development. UGMS stands ready, willing and able to do its part in assisting developers to avoid costly errors.





At right, vertical sections of split spoon samples that have been pressed on paper show deformations from depths of 20.5 and 50.5 feet below the surface of the landslide. ML = low plasticity silt; CL = low plasticity clay (Unified Soil Classification). Drawings are actual size.

BEAR LAKE VALUE CITED

"Environmental Geology of the Bear Lake Area, Utah, with Application to Planning in the Intermountain West" was the title of a paper presented at the AIME annual meeting by UGMS UGMS engineering geologist Bruce Kaliser. The meeting was held in Denver on February 16, 1970. Theme of the geological engineering session of the meeting was geology and the environment.

Kaliser, newly appointed membership chairman of the geological engineering unit committee of A. I. M. E., discussed the Bear Lake area in terms of its geological setting and potential development. The lake, lying half in Utah and half in Idaho, has a high recreation value, but the active Bear Lake Fault and the saturated unconsolidated sediments bordering the lake make earthquake damage a possibility to be taken into account in construction and development of land surrounding the lake. Ample groundwater of good quality is available.

According to Kaliser, the Rich County Commission, in whose jurisdiction the Utah half of Bear Lake lies, should anticipate increased urbanization in this area, and by creating zoning controls early, regulate the growth already starting. Also, Kaliser added, cooperation with Idaho agencies would enhance the recreational value of the lake for both states.

U. S. BUREAU OF MINES OFFICE MOVES

Utah's congressional delegation jointly introducted legislation in the Congress which would permit the U. S. Department of Interior to move its Bureau of Mines offices at 1600 East First South, Salt Lake City, on the University of Utah campus, to the new University Research Park. Reason: "The university property is desperately needed for other purposes," according to university officials.

EARTHQUAKE EPICENTERS

General earthquake epicenters in or near Utah in September, October and November 1969, with dates of occurrence and approximate magnitude, are listed below:

DECEMBER		Magnitude
2	Near Salt Lake City	<1.5
2	San Rafael Swell	1.8
2	Southwest Wyoming, about 110 miles east of Logan	2.5
2	South of Sunnyside	2.0
4	Southwest Wyoming, about	
4	Near Kamas	2.9
9	South of Sunnyside	3.0
9	Near Cedar City	3.0
10	South of Sunnyside	3.5
11	San Rafael Swell	2.5
11	Southeast Idaho, north of Bear Lake	3.0
13	South of Sunnyside	2.5
20	Near Logan	2.2
22	Rangeley, Colorado	no mag.
30	Ephraim	3.0
30	South of Sunnyside	2.0
	(10 rockbursts in December)	

JANUARY		Magnitude
3	Promontory Point	1.8
6	South of Sunnyside	2.0
6	South of Sunnyside	2.0
6	Near Cedar City	<1.5
8	Near Salt Lake City	<2.0
13	Near Delta	2.5
15	South of Sunnyside	2.3
15	Near Salt Lake City	1.5
21	South of Sunnyside	2.5
22	Near Price	3.0
22	Near Ouray	3.5
22	South of Sunnyside	2.5
22	Promontory Point	2.0
25	Southwest Idaho	3.0
26	Near Salt Lake City	1.5
27	Near Bloom	2.6
29	Southeast Idaho	2.5
30	South of Sunnyside	<2.0
31	South of Sunnyside	2.0
	(26 rockbursts in January)	

FEBRUARY		Magnitude
2	Southeast Nevada	2.8
2	Near Cedar City	2.0
3	Near Blanding	2.6
3	Southeast Utah	3.0
6	San Rafael Swell	2.8
8	South of Sunnyside	2.0
8	Southeast Nevada	2.8
11	Near Salt Lake City	<2.0
11	Near Cedar City	2.0
12	Near Cedar City	<2.0
12	Near Cedar Spring (west of Promontory)	<2.3
16	Near Delta	<2.0
21	Hillcreek Area (south of Ouray)	3.6
23	Near Salt Lake City	<2.0
25	Lund	2.7
25	Near Salt Lake City	2.0
28	South of Sunnyside	2.1
28	South of Sunnyside	2.2
	(27 rockbursts in February).	

These earthquakes were recorded by the University of Utah seismograph stations under the direction of Kenneth L. Cook. All locations and magnitudes are preliminary determinations; final determinations will be printed in the University of Utah Seismological Bulletin, issued quarterly.

ARE WELL LOGS GOOD LOGS?

About 150 lithologic logs of oil and gas test wells have been purchased at greatly reduced prices for the UGMS sample library collection. Obtained from a commercial logging service, most are from wells in San Juan, Kane, Garfield, Wayne, Emery and Grand counties. Use of the logs will be restricted to the sample library premises.

USGS OPEN FILE

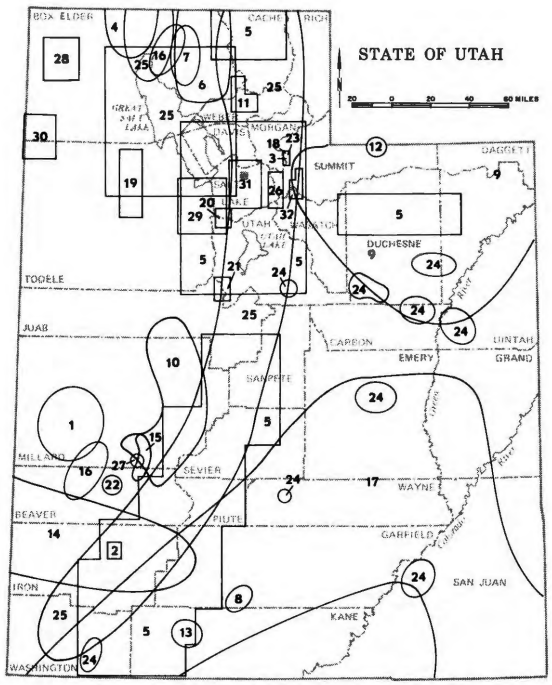
The U. S. Geological Survey has released in open files the following maps. Copies are available for inspection in the Geological Survey Libraries in Washington, D. C., Denver, Colo., Menlo Park, Calif., and 8102 Federal Office Bldg., Salt Lake City.

Preliminary geologic map and cross section of the Cherry Creek quadrangle and adjacent part of the Dutch Peak quadrangle, Juab County, Utah, by H. T. Morris and R. W. Kopf. 2 maps, explanation, cross section (4 sheets), scale 1:24,000.

Preliminary geologic map and cross section of the Maple Peak quadrangle and adjacent part of the Sabie Mountain quadrangle, Juab County, Utah, by H. T. Morris and R. W. Kopf. 2 maps, explanation, cross section (4 sheets), scale 1:24,000.

Summer Field Work in Utah

The geologists who plan to work in Utah during the 1970 field season are listed below. The reference numbers in the left column correspond as far as possible with the location numbers on the accompanying map.



1. Armstrong, R. L., Yale University — K-Ar dating of Tertiary volcanics from Millard County.
2. Averitt, P., and R. L. Threet USGS — Areal geology, Cedar City quadrangle.
3. Bailey, G. B. Univ. of Iowa — Wall rock alteration associated with Park Utah and Ontario veins.
4. Baker, C. H., Jr. USGS — Water resources of Curlew Valley, Utah-Idaho.
5. Baranzangi, M., and M. Sbar Lamont-Doherty Geol. Observatory — Seismic activity along major fault zones.
6. Bjorklund, L. J. USGS — Groundwater resources of eastern Box Elder County.
7. Bolke, E. L. USGS — Hydrologic reconnaissance of Blue Spring Creek valley.
8. Bushman, J. R. BYU — Spore and pollen zonation of Wahweap Formation.
9. Clark, J. Field Museum of Natural History — Uintan and Duchesnean paleography of Uinta Basin.
10. Condie, K. C. Washington Univ. — Mapping of Cenozoic basalts in Black Rock Desert, Millard, Beaver and Juab counties.
11. Crittenden, M. D., Jr. USGS — Mapping of Precambrian rocks of Huntsville area.
12. Crockett, D. H. U. S. Forest Service — Geohydrology of E. Fork of Smith Fork, north slope Uinta Mtns.
13. Goode, H. D. Univ. of Utah — Mapping of quadrangle, Skutumpah, Kane County (field geology course).
14. Grant, S. K. Univ. of Missouri at Rolla — Lab. analysis of samples of Lund tuff member, Needles Range Formation.
15. Herber, L. J. Univ. of Nevada — Order-disorder in coexisting plagioclase and alkali feldspar from Mineral Mtns.
16. Hood, J. W. USGS — 1. Hydrologic reconnaissance of Hansel Valley and Rozel Flat. 2. Hydrologic reconnaissance of Wah Wah Valley.
17. Johnson, A. H. Univ. of Oklahoma — Paleomagnetism of Jurassic rocks of south central Utah.
18. Johnson, S. Univ. of Wisconsin — Sulfide mineralogy of Humbug and East Flank ore bodies.
19. Maurer, R. E State Univ. of New York, College at Oswego — Geology of Cedar Mtns., Tooele County.
20. Moore, W. J. USGS — Igneous rocks of Bingham mining dist.
21. Morris, H. T. USGS — Geologic, geochemical study in East Tintic mining dist.
22. Mower, R. W. USGS — Groundwater resources of Milford area, Escalante Desert.
23. Nash, T. USGS — Fluid inclusion studies of Park City ores.
24. Ritzma, H. R. Utah Geol. and Mineralog. Survey — Oil-impregnated rock deposits
25. Smith, R. B. Univ. of Utah — 1. Microearthquake study of fault zones and induced earthquake areas. 2. Seismic and magnetic survey of Great Salt Lake.
26. Smith, R. K. Univ. of Iowa — Contact metamorphism around Alta stock.
27. Strahan, R., and R. Neudeck Western Minerals Exploration Co. — Mineral exploration at north end of Mineral Mtns.
28. Todd, V. Stanford Univ. — History of metamorphism and deformation in S. Grouse Cr.
29. Tooker, E. W. USGS — Mapping in Oquirrh Mtns. (Bingham Mining dist.).
30. Turk, L. J. Stanford Univ. — Hydrogeology of Bonneville Salt Flats.
31. Van Horn, R. USGS — Field and aerial mapping, Salt Lake City and vicinity.
32. Woodfill, R. D. Purdue Univ. — Mapping and petrographic analysis, Keetley volcanics.

Gas Injection Begins at Bridger Lake

A miscible flood project—injection of natural gas to increase recovery of oil—will begin operating in the Bridger Lake field, Summit County, in 1970. Phillips Petroleum, operator of the field, outlined the scheme in its application to the Utah Oil and Gas Conservation Commission which approved it.

Production of oil with accompanying gas since 1966 had been characterized by a marked decline of reservoir pressures, causing concern for the ultimate maximum recovery of oil known to be present. Oil at Bridger Lake is produced flowing from an average depth of 15,600 feet from a lower Dakota Formation sandstone (Cretaceous age).

The Phillips plan is to produce the field as a closed system. Natural gas purchased from Wyoming fields from Mountain Fuel Supply will be piped to Bridger Lake and injected under pressure into a well in the center of the field. Pressures in the Dakota sandstone pay zone will be gradually increased to near the original reservoir pressure by controlling production in surrounding wells.

Gas mixing with oil and spreading outward from the central area of injection will enter surrounding producing wells and carry a foamy mixture of gas and oil flowing to the surface. Here gas and oil will be separated and the recovered gas re-injected into the formation. Gas used to fuel the operation and some temporarily "lost" to the sandstone will be replaced by purchased gas. Years from now, as the ratio of gas to oil rises in the wells, excess gas will be sold back to Mountain Fuel.

The porous sandstone reservoir at Bridger Lake is known as an irregular body, pod-shaped in cross section, probably an ancient river channel (see accompanying diagram). Oil is trapped in the sandstone by impermeable shales above, below and around the sides. At lower structural levels in the field, the oil is floating on water which tends to press the oil upward into the trap.

The field had produced 3,429,000 barrels of oil by the end of 1969. It is expected to produce up to 40 million barrels from 12 or so wells. Recovery per well—more than 3 million barrels each—is a remarkable conservation objective to shoot for.

Newest field well, Phillips No. 8 Fork-A, SW NW 36-3N-14E, completed in January flowing 516 barrels per day, is the first located on State land This well is expected to generate nearly $1 million in royalties to Utah during its decades of production.

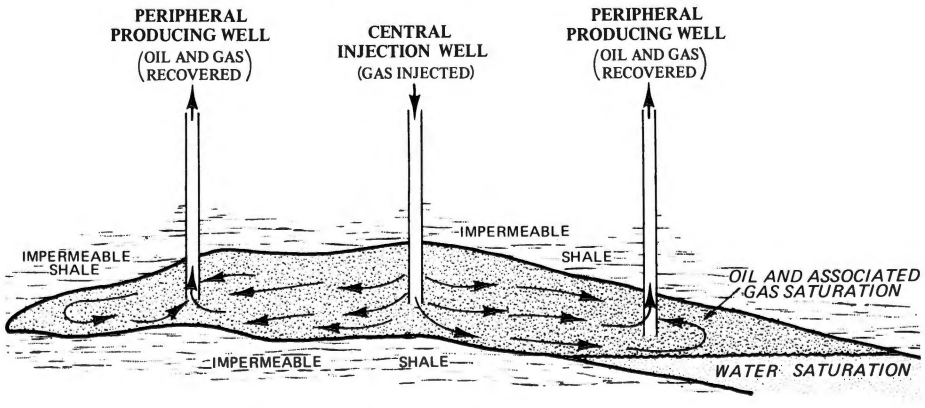


Diagram of the gas injection process.

Drilling operations at Bridger Lake Field, Summit County. (Photo courtesy Phillips Petroleum Company)

LEGISLATIVE SESSION

Utah's first 20-day budget session of the Legislature adjourned January 31. The legislators pared $2.5 million from Gov. Rampton's $487.7 million budget. In keeping with their expressed resolves prior to the opening of the session, the Governor and legislative leaders avoided increases in tax rates. The lawmakers passed a "Common Day of Rest Act" requiring most retail establishments to close on Sunday unless they should elect to close on Saturday. The Governor let it become law without his signature. It includes an exemption covering "the mining and processing of natural resources."

DOUBLETAKE

Have you looked recently at the postmark on your mail from Westinghouse? Ours reads, "The ocean's bottom is more interesting than the moon's behind."

Utah Geology in Print

A list of papers appearing in 1969 which pertain to the geology and mineral industry in Utah has been prepared and printed below. Papers appearing in 1967 and 1968 and not included in the 1969 list have been included.

The staff of the University of Utah Engineering and Physical Sciences Library, under the direction of Edith Rich, generously provided the Quarterly Review staff with the list of papers.

The papers are listed alphabetically by author and by subject.

The following sources were used to provide information:

Abstracts of North America Geology.

Geological Society of America, Bibliography and Index of Geology.

Publications of the U. S. Geological Survey 1969.

Utah Geological Survey 1969.

Applied Science and Technology Index, Vol. 57, No. 3 and No. 6.

Engineering Index Monthly, 1969.

Theses from University of Utah and Brigham Young University.

Miscellaneous.

ABOU-ZIED, M. S., 1969, Geology and mineralogy of the Milford Flat quadrangle and the Old Moscow mine, Star District, Beaver County, Utah [abs.]: Dissert. Abs. Sec. B, Sci. and Eng., v. 29 (7), p. 2490B-2491B.

ARMSTRONG, R. L., 1969, Geochronology of the eastern Basin and Range province, eastern Nevada and western Utah and the Colorado plateau, Utah, Colorado, Arizona and New Mexico [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 2.

ARNOW, TED, and J. W. Hood, 1969, Field trip road log—Great Salt Lake and Antelope Island, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 261-266.

BAARS, D. L., ed., 1969, Geology and natural history of the Grand Canyon region, Fifth Field Conference, Powell Centennial River Expedition: Four Corners Geol. Soc., 212 p., illus.

BAER, J. L., 1969, Paleoecology of cyclic sediments of the lower Green River Formation, central Utah: Ph. D. dissert., Brigham Young Univ.

BAETCKE, G. B., 1969, Stratigraphy of the Star Range and reconnaissance study of three selected mines: Ph. D. dissert., Univ. of Utah.

BAKER, C. H., Jr., 1969, Hot pots near Midway, Utah [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 4.

BAKER, C. H., Jr., 1968, Thermal springs near Midway, Utah, *in* Geological Survey Research, 1968, Chap. D: U. S. Geol Survey Prof. Paper 600-D, p. D63-D70, illus.

BALSLEY, J. K., 1969, Origin of fossiliferous concretions in the Ferron sandstone, southeastern Utah: M. S. thesis, Univ. of Utah.

BARNES, M. P., and J. G. Simos, 1968, Ore deposits of the Park City district with a contribution on the Mayflower lode, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 2, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 1102-1126, illus.

BEER, L. P., 1968, Ground-water hydrology of southern Cache Valley, Utah [abs.]: Dissert. Abs., v. 28 (7), p. 2858B-2859B.

BELT, C. B., Jr., 1969, Preliminary geochemical study of the Alta and Clayton Peak intrusives, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 111-123, illus.

BIRDSEYE, H. S., 1969, Geothermal power resources in the Southwest, *in* Exploration for mineral resources—4th Ann. Idea Conf., 1968: New Mexico Bur. Mines and Mineral Resources Circ. 101, p. 86-96, illus.

BISSELL, H. J., 1969, Permian and Lower Triassic transition from the shelf to basin, Grand Canyon, Arizona, to Spring Mountains, Nevada, *in* Geology and natural history of the Grand Canyon region, Fifth Field Conference, Powell Centennial River Expedition: Four Corners Geol. Soc., p. 135-169, illus.

BLANK, H. R., and E. H. McKee, 1969, Chemical variations and K-Ar ages of volcanic rocks in the Bull Valley district, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 3 (Cordilleran Sec.), p. 7.

BOOY, E. C., 1969, Mineralogy and physical properties of clays involved in certain cordilleran landslides [abs.]: Dissert. Abs. Int., v. 30 (2), p. 706B-707B.

BOWMAN, J. L., 1969, Oil-impregnated sandstones between Dirty Devil and Colorado and Green rivers, Garfield and Wayne counties, Utah [abs.]: Am. Assoc. Petrol. Geol. Bull., v. 53 (1), p. 218.

BRAY, R. E., 1969, Igneous rocks and hydrothermal alteration at Bingham, Utah: Econ. Geology, v. 64 (1), p. 34-49, illus.

BUDGE, D. R., 1969, Late Ordovician and Silurian coral communities, eastern Great Basin [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 10-11.

BURKE, J. J., 1969, An antiacodont from the Green River Eocene of Utah: Kirtlandia, No. 5, 7 p., illus.

BUSHMAN, J. R., 1969, Palynology of the Spotten Cave archaeological site, Santaquin, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 11.

BUTTGEREIT, C. D., 1969, Residual analysis of potential field data over structures in Utah and Colorado [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 11-12.

CAMBELL, J. A., 1969, Upper Valley oil field, Garfield County, Utah, *in* Geology and natural history of the Grand Canyon region—Four Corners Geol. Soc., 5th Field Conf., Powell Centennial River Exped. [Durango, Colo.]: Four Corners Geol. Soc., p. 195-200, illus.

CATALOG: Library of samples for geological research, 2nd supplement to consolidated index: 1951-1966 material added in 1968: Utah Geol. and Mineralog. Survey, 12 p.

CHAMBERLAIN, C. K., 1969, Carboniferous trilobites; Utah species and evolution in North America: Jour. Paleontology, v. 43 (1), p. 41-67, illus.

CHAPUSA, F. W. P., 1969, Geology and structure of Stansbury Island: M. S. thesis, Univ. of Utah.

CHEMINEE, J., R. Letolle and P. Olive, 1969, Premieres donnees isotopiques sur des fumerolles de volcans italiens (First isotopic data on the fumaroles of Italian volcanoes): Bull. Volcanol., v. 32 (3), p. 469-475.

COBBAN, W. A., 1969, The Late Cretaceous ammonites *Scaphites leei* Reeside and *S. hippocrepis* (DeKay) in the western interior of the United States: U. S. Geol. Survey Prof. Paper 619, 29 p.

COHENOUR, R. E., 1969, Uranium in Utah, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 231-249, illus., tables.

COMPTON, R. R., 1969, Thrusting in northwest Utah [abs.]: Geol. Soc. Amer., abs., pt. 5 (Rocky Mtn. Sec.), p. 15.

CONDIE, K. C., 1969, Geologic evolution of the Precambrian rocks in northern Utah and adjacent areas, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 71-95, illus.

COOK, K. L., R. M. Iverson and M. T. Strohmeirer, 1969, Bottom gravity meter survey of the Great Salt Lake, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 16, also *in* Eos (Amer. Geophys. Union, Trans.), v. 50 (4), p. 321.

COOK, K. L., and M. M. M. Khattab, 1969, Thrusting in northwestern Utah indicated by gravity and magnetic surveys [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 17.

COOK, K. L., and others, 1969, Strain measurements near the Wasatch fault, Utah [abs.]: Eos (Amer. Geophys. Union, Trans.), v. 50 (4), p. 243.

COOK, P. J., 1969, The petrology and geochemistry of the Meade Park member of the Phosphoria Formation [abs.]: Dissert. Abs. Int., v. 30 (2), p. 707B.

COOLEY, M. E., J. W. Harshbarger, J. P. Akers and W. F. Hardt, 1969, Regional hydrogeology of the Navajo and Hopi Indian reservations, Arizona, New Mexico and Utah, with a section on Vegetation by O. N. Hicks: U. S. Geol. Survey Prof. Paper 521-A, p. A1-A61, illus., tables, geol. map.

COSTAIN, J. K., and P. M. Wright, 1969, Heat flow and precision temperature measurements in boreholes, in SPWLA Logging Symposium, 10th Ann., Houston, Tex., 1969, Trans.: Houston, Tex., Soc. Prof.

(Continued on next page)

(Continued from preceding page)

Well Log Analysis, p. J1-J21, illus.

COTTER, E., 1969, Identification and interpretation of Upper Cretaceous fluvial and deltaic sandstones [abs.]: Am. Assoc. Petrol. Geol. Bull., v. 53 (3), p. 713-714.

CRITTENDEN, M. D., Jr., 1969, Interaction between Sevier orogenic belt and Uinta structures near Salt Lake City, Utah [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 18.

CROSBY, G. W., 1969, Radial movements in the western Wyoming salient of the Cordilleran overthrust belt: Geol. Soc. America Bull., v. 80 (6), p. 1061-1077, illus.

CUSHING, B. C., 1969, Graveyard of prehistoric monsters: Our Public Lands, v. 19 (1), p. 8-9, illus.

DALNESS, W. M., 1969, The Parunuweap Formation in the vicinity of Zion National Park, Utah: M. S. thesis, Univ. of Utah.

DAVIDSON, D. M. Jr., 1969, Ore emplacement and associated features, Kane Springs Canyon, Utah [abs.]: Dissert. Abs., Sec. B, Sci, and Eng., v. 29 (9), p. 3362B-3363B.

DEMIRMEN, F., 1969, Petrographic and statistical study of part of Pennsylvanian Honaker Trail Formation, southeastern Utah [abs.]: Dissert. Abs. Int., v. 30 (4), p. 1751B.

DOELLING, H. H., 1969, Mineral resources, San Juan County, Utah, and adjacent areas: Uranium: Utah geol. and Mineralog. Survey Special Studies 24, pt. 2, 64 p.

DOELLING, H. H., 1968, Utah oddities lure rock hounds: Utah Geol. and Mineralog. Survey Quart. Rev., v. 2 (3), p. 7, illus.

EARDLEY, A. J., 1969, Charting the Laramide structures of western Utah, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 51-70, illus.

EARDLEY, A. J., 1969, Chloride fall-out in the Great Salt Lake watershed [abs.]: Geol. Soc. Amer, Abs., pt. 5 (Rocky Mtn. Sec.), p. 21.

EARDLEY, A. J., 1969, Field trip road log—Willard thrust, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 257-259.

EARDLEY, A. J., 1969, Willard thrust and the Cache uplift: Geol. Soc. Amer., Bull., v. 80 (4), p. 669-680, illus.

ERICKSON, A. J., Jr., 1969, Ore deposits of the Park City mining district [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 22-23.

EVERETT, A. G., 1969, Petrology and trace element chemistry of the Carmel Formation (Jurassic), Iron Springs mining district, Utah [abs.]: Dissert. Abs., Sec. B, Sci, and Eng., v. 29 (10), p. 3788B-3789B.

FOX, R. C., 1969, Regional gravity survey of part of the Kaiparowits region, Kane and Garfield counties, Utah, with profiles across the Paunsaugunt fault [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 24-25.

FRONDEL, C., and R. M. Honea, 1968, Billingsleyite, a new silver sulfosalt: Am. Mineralogist, v. 53 (11, 12), p. 1791-1798.

GARMOE, W. J., 1968, Breccia structures in the Ontario mine, Park City district, Utah, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 2, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 1127.

GARVIN, R. F., 1969, Stratigraphy and economic significance, Currant Creek Formation, northwest Uinta Basin: Utah Geol. and Mineralog. Survey Spec. Studies 27, 62 p., illus.

GILLULY, J., 1969, Chronology of intrusion, volcanism and ore deposition at Bingham, Utah [discussion of paper by W. J. Moore, M. A. Lanphere, and J. D. Obradovich, 1968]: Econ. Geology, v. 64 (2), p. 228.

GOODE, H. D., 1969, Estimated potential of Navajo Sandstone as an aquifer west of Escalante anticline, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p 28.

HANSEN, W. R., 1969, The geologic story of the Uinta Mountains: U. S. Geol. Survey Bull. 1291, 144 p., illus.

HANSEN, W. R., 1969, Tertiary drainage development across the Uinta Mountains—a review [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 30-31.

HANSHAW, B. B., and others, 1969, Geochemistry and hydrodynamics of the Paradox Basin region, Utah, Colorado and New Mexico, *in* Geochemistry of subsurface brines: Chem. Geol., v. 4 (1-2), p. 263-294, illus.

HELMSTAEDT, H., and others, 1969, Petrofabrics of mafic and ultramafic inclusions and kimberlite pipes in southeastern Utah and northeastern Arizona [abs.]: Eos (Amer. Geophys. Union, Trans.), v. 50 (4), p. 345.

HELSLEY, C. E., 1969, Paleomagnetic evidence for time-transgressive lithologic units in the Moenkopi Formation [abs.]: Eos (Amer. Geophys. Union, Trans.), v. 50 (11), p. 607.

HENDERSON, G. V., 1969, The origin of pyrophyllite-rectorite in shales of north central Utah [abs.]: Dissert. Abs. Int., v. 30 (3), p. 1201B.

HERBER, L. J., 1969, Order-disorder in coexisting plagioclase and alkali feldspar from the Mineral Range of southwest Utah [abs.]: Dissert. Abs., Sec. B. Sci. and Eng., v. 29 (10), p. 3789B-3790B.

HEWITT, W. P., 1968, Western Utah, eastern and central Nevada, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 1, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 857-885, illus.

HIGH, L. R., Jr., and M. D. Picard, 1969, Sedimentary cycles in Green River Formation (Eocene): modification of Walther's law [abs.]: Amer. Assoc. Petrol. Geol. Bull., v. 53 (3), p. 722-723, also *in* 1969, Geol. Soc. Amer. Abs., pt. 6 (North-Central Sec.), p. 21.

HINTZE, L. F., 1969, Normal faults in the Wasatch Range at Provo, Utah [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 32.

HITE, R. J., 1968, Salt deposits of the Paradox Basin, southeast Utah and southwest Colorado, *in* Saline deposits: Geol. Soc. Amer., Spec. Paper 88, p. 319-330, illus.

HOGGAN, R. D., 1969, Paleontology and paleoecology of the Upper Jurassic Curtis Formation in the Uinta Mountains, Daggett County, Utah [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 32.

HOLLAND, J. L., D. H. Griswold and B. L. Bridges, 1969, Silver Lake Flats dam and reservoir site, American Fork-Dry Creek watershed, Utah [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 33.

HOWARD, J. D., 1969, The influence of channel deposits on Upper Cretaceous sedimentation and their effect on coal mining [abs.]: Geol. Soc. Amer., Abs., pt. 5 (Rocky Mtn. Sec.), p. 34-35.

HUNT, C. B., 1969, Geologic history of the Colorado River, *in* The Colorado River region and John Wesley Powell: U. S. Geol. Survey Prof. Paper 669-C, p. 59-130, illus.

ISHERWOOD, W. F., 1969, Regional gravity survey of parts of Millard, Juab and Sevier counties, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 35.

JACOB, A. F., 1969, Delta facies, Green River Formation, Carbon and Duchesne counties, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 36-37.

JAMES, A. H., 1969, Hypothetical diagrams of several porphyry copper deposits [abs.]: Geol. Soc. Amer. Abs., pt. 7 (Ann. Meet.), p. 114.

JAMES, A., W. Smith, R. E. Bray and E. C. John, 1969, Bingham district—a zoned porphyry ore deposit, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 200-212, illus.; originally published 1961.

JENSEN, M. L., ed., 1969, Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, 266 p. illus.

JONES, L. M., and G. Faure, 1969, The isotope geochemistry of strontium in Great Salt Lake, Utah [abs.]: Geol. Soc. Amer. abs., pt. 6, (North-Central Sec.), p. 24.

KATTELMAN, D. F., 1968, Geology of the Desert Mountain intrusives, Juab County, Utah: Brigham Young Univ. Geology Studies, v. 15 (1), p. 85-107, illus.

KENNECOTT COPPER CORPORATION, Tintic Division, 1969, Geology and ore deposits of the Tintic mining districts [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 39.

KEPPER, J., 1969, Middle and early Late Cambrian algal biostromes and regional dolomitization in Great Basin [abs.]: Amer. Assoc. Petrol. Geol. Bull., v. 53 (3), p. 726.

KERR, P. F., 1968, The Marysvale, Utah, uranium deposits, in Ore deposits of the United States, 1933-1967: Graton-Sales v. 2, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 1020-1042, illus.

KHATTAB, M. M. M., 1969, Gravity and

(Continued on next page)

(Continued from preceding page)

magnetic surveys of the Grouse Creek Mountains and the Raft River Mountains area and vicinity, Utah and Idaho: Ph.D. dissert., Univ. of Utah.

KIER, P. M., 1968, The Triassic echinoids of North America: Jour. Paleontology, v. 42 (4), p. 1000-1006, illus.

KILBOURNE, D. E., 1969, Paleomagnetism of some rocks from the Mesaverde group, southwestern Wyoming and northeastern Utah: Geol. Soc. Amer. Bull., v. 80 (10), p. 2069-2073, illus.

LESSENTINE, R. H., 1969, Kaiparowits and Black Mesa basins; stratigraphic synthesis, *in* Geology and natural history of the Grand Canyon region, Fifth Field Conference, Powell Centennial River Expedition: Four Corners Geol. Soc., p. 91-113, illus., (Reprint: Amer. Assoc. Petrol. Geol. Bull., v. 49 (11), p. 1997-2019).

LINDSAY, J. B., ed., 1969, Geologic guidebook of the Uinta Mountains 16th annual field conference: Intermountain Assoc. Geol. *and* Utah Geol. and Mineralog. Survey, 237 p., illus.

LOHRENGEL, C. F., 2d., 1969, Palynology of Kaiparowits Formation, Garfield County, Utah [abs.]: Am. Assoc. Petrol. Geol. Bull., v. 53 (3), p. 729.

LOVERING, T. S., H. T. Morris and M. L. Jensen, 1969, Field trip road logs—Tintic mining district, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 253-256.

MACKIN, J. H., 1968, Iron ore deposits of the Iron Springs district, southwestern Utah, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 2, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 992-1010, illus.

MADSEN, J. H., Jr., 1969, This business of dinosaurs [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 48-49.

MADISON, R. J., 1969, Hydrology and chemistry of Great Salt Lake, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 140-157, illus.

MALAN, R. C., 1968, The uranium mining industry and geology of the Monument Valley and White Canyon districts, Arizona and Utah, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 1, New York, Am. Inst. Mining Metall. and Petroleum Engineers, p. 790-804, illus.

MARSELL, R. E., 1969, Tracing ground-water movements in the Uinta Mountains, Utah, by means of dye tests [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 50.

MARSELL, R. E., 1969, The Wasatch fault zone in north central Utah, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 124-139, illus.

MARVITT, J. P., 1969, Prehistoric man in Utah—a summary, *in* Guidebook of Northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 21-35, illus.

MARZOLF, J. E., 1969, Regional stratigraphic variations in primary features of the Navajo Sandstone, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 3 (Cordilleran Sec.), p. 40, pt. 5 (Rocky Mtn. Sec.), p. 50-51.

MATTICK, R. E., 1968, Seismic-refraction profiles across six canyons in the Wasatch Range near Salt Lake City, Utah, *in* Geological Survey Research 1968, Chap. D: U. S. Geol. Survey Prof. Paper 600-D, p. D231-D257.

MATTOX, R. B., 1968, Upheaval Dome, a possible salt dome in the Paradox basin, Utah: *in* Saline deposits, Geol. Soc. Amer., Spec. Paper No. 88, p. 331-347, illus.

MAUGER, R. L., 1969, Relations between mineral deposits and igneous activity in the Park City, Tintic and Bingham, Utah, districts [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 51.

MC CARTHY, J. H., Jr., R. E. Learned, J. M. Botbol, T. G. Lovering, J. R. Watterson and R. L. Turner, 1969, Gold-bearing jasperoid in the Drum Mountains, Juab and Millard counties, Utah: U. S. Geol. Survey Circ. 623, 4 p., illus.

MC CORMICK, C. D., and M. D. Picard, 1969, Petrology of Gartra member (Triassic), Unita Mountain area, Utah and Colorado [abs.]: Geol. Soc. Amer. Abs. pt. 5 (Rocky Mtn. Sec.), p. 51-52.

MC GETCHIN, T. R., 1969, Moses Rock dike; geology, petrology and mode of emplacement of a kimberlite-bearing breccia dike, San Juan County, Utah [abs.]: Dissert. Abs. Int., v. 30 (1), p. 259B.

MC GETCHIN, T. R., 1969, Source and emplacement of kimberlite at Moses Rock dike, Utah. Symposium on volcanoes and their roots, Oxford, 1969, v. Abs., p. 41, Int. Assoc. Volcanol. Chem. Earth's Interior, Oxford Univ., Dept. Geol. Minerals, also *in* Eos (Amer. Geophys. Union, Trans.), v. 50 (4), p. 345.

MC KEE, E. D., 1969, Paleozoic rocks of Grand Canyon, *in* Geology and natural history of the Grand Canyon region, Fifth Field Conference, Powell Centennial River Expedition: Four Corners Geol. Soc., p. 78-90, illus.

MEAD, C. W., and M. E. Mrose, 1968, Solving problems in phosphate mineralogy with the electron probe, in Geological Survey Research 1968, Chap. D: U. S. Geol. Survey Prof. Paper 600-D, p. D204-D206, illus.

MELANKHOLINA, Y. N., 1967, Nevadan folded system of the southern Cordillera. (translated title): Akad. Nauk SSSR, Geol. Inst., Tr., No. 180, 71 p., (Russ.), illus.

MILLER, J. F., 1969, Conodont fauna of the Notch Peak Limestone (Cambro-Ordovician), House Range, Utah: Jour. Paleontology, v. 43 (2), p. 413-439, illus.

MITTERER, R. M., 1969, The origin of calcareous oolites [abs.]: Geol. Soc. Amer. Abs., pt. 4 (Southeast Sec.), p. 54-55.

MOLENAAR, C. M., compiler, 1969, Lexicon stratigraphic names used in northern Arizona and southern Utah east of the Paleozoic hinge line, *in* Geology and natural history of the Grand Canyon region—Four Corners Geol. Soc., 5th Field Conf., Powell Centennial River Exped., 1969 [Durango, Colo.]: Four Corners Geol. Soc., p. 68-77.

MOORE, W. J., 1969, Igneous rocks in the Bingham mining district, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 54.

MOORE, W. J., M. A. Lanphere and J. D. Obradovich, 1969, Chronology of intrusion, volcanism and ore deposition at Bingham, Utah—a reply [to discussion by J. Gilluly, 1969]: Econ. Geology, v. 64 (2), p. 229.

MORRIS, H. T., 1968, The main Tintic mining district, Utah, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 2, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 1043-1073, illus.

MORRIS, H. T., and R. W. Kopf, 1969, Tintic Valley thrust and associated low-angle faults, central Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5, (Rocky Mtn. Sec.), p. 55-56, table.

MOUSSA, M. T., 1968, Fossil tracks from the Green River Formation (Eocene) near Soldier Summit, Utah: Jour. Paleontology, v. 42 (6), p. 1433-1438, illus.

MOUSSA, M. T., 1969, Green River Formation (Eocene) in the Soldier Summit area, Utah: Geol. Soc. Amer. Bull., v. 80 (9), p. 1737-1748.

MOWER, R. W., 1969, Electric analog model in water-resources investigation of Salt Lake County, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 56-57.

MOWER, R. W., 1968, Ground-water discharge toward Great Salt Lake through valley fill in the Jordan Valley, Utah, *in* Geological Survey Research 1968, Chap. D: U. S. Geol. Survey Prof. Paper 600-D, p. D-71-D74, illus.

MOWER, R. W., 1969, Ground-water hydrology of the Jordan Valley, Utah, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 158-173, illus.

MULLENS, T. E., 1969, Geologic map of the Causey Dam quadrangle, Weber County, Utah: U. S. Geol. Survey Geol. Quad. Map GQ-790, scale 1:24,000, sections, text.

MULLENS, T. E., and M. D. Crittenden, Jr., 1969, Cretaceous age of the Willard Thrust, Weber County, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 57.

MUTSCHLER, F. E., and R. J. Hite, 1969, Origin of the Meander anticline, Cataract Canyon, Utah, and basement fault control of Colorado River drainage [abs.]: Geol. Soc. Amer. Abs., pt. 5, (Rocky Mtn. Sec.), p. 57-58.

NAESER, C. W., and D. E. Stuart-Alexander, 1969, The age and temperature of the Mule Ear diatreme, southeastern Utah [abs.]: Geol. Soc. Amer. Abs., pt. 7 (Ann. Meet.), p. 155-156.

NELSON, R. B., 1969, Relation and history of structures in a sedimentary succession with deeper metamorphic structures, eastern Great Basin: Am. Assoc. Petrol. Geol. Bull., v. 53 (2), p. 307-339, illus.

NICOL, A., 1969, Detection of pre-slip rota-

(Continued on next page)

(Continued from preceding page)

tional strains in unstable slopes [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 58.

NYQUIST, D., 1968, Eutrophication trends of Bear Lake, Idaho-Utah, and their effect on the distribution and biological productivity of zooplankton [abs.]: Dissert. Abs., Sec. B, Sci. and Eng., v. 29 (5), p. 1560-1561B.

O'NEILL, J. M., 1969, Structural geology of the southern Pilot range, Elko county, Nevada, and Box Elder and Tooele counties, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 61.

ORLANSKY, R., 1969, Significance of palynomorphs as sedimentation indicators in Cretaceous Straight Cliffs sandstone, Utah [abs.]: Amer. Assoc. Petrol. Geol. Bull., v. 53 (3), p. 734-735.

OSTERWALD, C. R., C. R. Dunrud and J. O. Maberry, 1969, Preliminary geologic map of the Columbia area, Carbon and Emery counties, Utah (two sheets, scale 1:6,000): U. S. Geol. Survey Miscellaneous Geologic Investigations Map I-582.

PALMER, D. E., 1969, Structure and stratigraphy of Stansbury Island, Tooele County, Utah [abs.]: Geol. Soc. Amer. Abs.. 1969, pt. 5 (Rocky Mtn. Sec.), p. 62.

PANKINA, R. G., 1967, The isotopic composition of sulfur and hydrogen in petroleum as an indicator of certain paleogeochemical conditions in an oil-forming basin (translated title): Geokhim., No. 5, p. 583-586 (Engl. sum.).

PARRY, W. T., W. D. Hurley and A. Nicol, 1969, Engineering geology of some northern Utah landslides, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 192-199, illus., table.

PETERSEN, M. S., 1969, The occurrence of ammonoids from the lower Deseret limestone, northern Stansbury mountains, Tooele County, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 63.

PETERSON, F., 1969, Four new members of the Upper Cretaceous Straight Cliffs Formation in the southeastern Kaiparowits region, Kane County: U. S. Geol. Survey Bull. 1274-J, p. J1-J28, illus.

PETERSON, J. A., 1968, Regional stratigraphy of the Paradox Basin, Utah and Colorado [abs.], *in* Saline deposits: Geol. Soc. Amer. Spec. Paper (88), p. 412-413.

PETERSON, J. A., and R. J. Hite, 1969, Pennsylvanian evaporite-carbonate cycles and their relation to petroleum occurrence, southern Rocky Mountains, *in* Evaporites and petroleum, Amer. Assoc. Petrol. Geol. Bull., v. 53 (4), p. 884-908, illus.

PICARD, M. D., and L. R. High, Jr., 1969, Some sedimentary structures resulting from flash floods, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 175-190, illus.

POLLARD, D. D., 1969, Deformation of host rocks during sill and laccolith formation [abs.]: Dissert. Abs. Int., v. 30 (3), p. 1204-1205B.

POLLARD, D. D., and A. M. Johnson, 1969, Sill-laccolith-bysmalith; evolution of concordant intrusions in Henry Mountains of Utah [abs.]: Geol. Soc. Amer. Abs., pt. 7 (Ann. Meet.), p. 180.

RADTKE, A. S., C. M. Taylor and H. T. Morris, 1969, Micromineralogy of galena ores, Burgin mine, East Tintic district, Utah: U. S. Geol. Survey Prof. Paper 614-A, p. A1-A17, illus.

REESE, D. L., 1969, Developments in Four Corners-Intermountain area in 1969: Amer. Assoc. Petrol. Geol. Bull., v. 53 (6), p. 1293-1296, illus.

REPENNING, C. A., M. E. Cooley and J. P. Akers, 1969, Stratigraphy of the Chinle and Moenkopi formations, Navajo and Hopi reservations, Arizona, New Mexico and Utah: U. S. Geol. Survey Prof. Paper 521-B, p. B1-B34, illus.

RICH, M., 1969, Petrographic analysis of Atokan carbonate rocks in central and southern Great Basin: Am. Assoc. Petrol. Geol. Bull., v. 53 (2), p. 340-366, illus.

RIGBY, J. K., 1969, A new Middle Cambrian hexactinellid sponge from western Utah: Jour. Paleontology, v. 43 (1), p. 125-128, illus.

RITZMA, H. R., 1968, Black gold in Utah's Circle Cliffs?: Utah Geol. and Mineralog. Survey Quart. Rev., v. 2 (4), p. 4, 5.

RITZMA, H. R., 1969, Petroleum potential of Utah [abs.]: Am. Assoc. Petrol. Geol. Bull., v. 53 (1), p. 217-218.

RITZMA, H. R., and H. H. Doelling, 1969, Mineral resources, San Juan County, Utah, and adjacent areas—Petroleum, potash, groundwater and miscellaneous minerals: Utah Geol. and Mineralog. Survey Spec. Studies 24, pt. 1, 125 p., illus.

RITZMA, H. R., and deB. K. Seeley, 1969, Determination of oil shale potential, Green River Formation, Uinta Basin, northeast Utah: Utah Geol. and Mineralog. Survey Spec. Studies 26, 16 p., illus.

ROBERTS, R. J., and E. W. Tooker, 1969, Age and regional significance of conglomerate in the Newfoundland and Silver Island Mountains, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 69.

ROBISON, R. A., 1969, Annelids from the middle Cambrian Spence shale of Utah: Jour. Paleontology, v. 43 (5), p. 1169-1173, illus.

ROBISON, R. A., 1968, Unusual Middle Cambrian fossils from northern Utah [abs.]: Utah Acad. Sci., Arts and Letters Proc., v. 45 (1), p. 320-321.

ROBISON, R. A., and J. Sprinkle, 1969, A new echinoderm from the Middle Cambrian of Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 69.

RODDY, D. J., and others, 1969, Shatter cones at TNT explosion craters [abs.]: Eos (Amer. Geophys. Union, Trans.), v. 50 (4), p. 220.

ROSS, R. J., Jr., 1969, Brachiopods from upper part of Garden City Formation (Ordovician), north-central Utah: U. S. Geol. Survey Prof. Paper 593-H 1968, p. H1-13.

ROWLEY, P. D., 1968, Geology of the southern Sevier Plateau, Utah [abs.]: Dissert. Abs., Sec. B, Sci. and Eng., v. 29 (6), p. 2091B.

RUBRIGHT, R. D., and O. J. Hart, 1968, Nonporphyry ores of the Bingham district, Utah, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 1, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 886-907, illus.

SANDBERG, C. A., and R. C. Gutschick, 1969, Stratigraphy and conodont zonation of type Leatham Formation (Devonian and Mississippian), Bear River Range, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 70-71.

SCHMITT, L. J., 1969, Uranium and copper mineralization in the Big Indian Wash-Lisbon Valley mining district, southeastern Utah [abs.]: Dissert. Abs. Int., v. 30 (2), p. 713B-714B.

SHAWE, D. R., 1969, Possible exploration targets for uranium deposits, south end of the Uravan mineral belt, Colorado-Utah, *in* Geological Survey Research 1969, Chap. B: U. S. Geol. Survey Prof. Paper 650-B, p. B73-B76, illus.

SHAWE, D. R., 1968, Geology of the Spor Mountain beryllium district, Utah, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 2, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 1148-1161, illus.

SHEPARD, W. M., H. T. Morris and D. R. Cook, 1969, Geology and ore deposits of East Tintic mining district, Utah, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 215-229, illus.; abridged 1969, originally published 1968; *and* Ore deposits of the United States, 1933-1967: Graton-Sales v. 1, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 941-965, illus., 1968.

SHOEMAKER, E. M., and others, 1968, Structure and history of the salt anticline of the Paradox Basin, Colorado and Utah [abs.], *in* Saline deposits: Geol. Soc. Amer., Spec. Paper 88, p. 415-416.

SHRODER, J. F., 1968, Landslides of Utah [abs.]: Dissert. Abs., v. 28 (7), p. 2907B.

SMITH, H. P., 1969, The Moenkopi group of north-central Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 74-75.

SMITH, H. P., 1969, The Thaynes Formation of the Moenkopi Group, north-central Utah: Ph. D. dissert., Univ. of Utah.

SMITH, R. B., 1969, A sub-bottom seismic profile from Promontory Point to Lakeside, Great Salt Lake, Utah [abs.]: Geol. Soc. Amer. Abs., p. 75.

SMITH, W. H., 1969, Geology of the Bingham mining district [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 75-76.

SMITH, W. H., and E. C. John, 1968, Geologic mapping techniques and applications at Kennecott's Utah Copper Division open pit mine at Bingham Canyon, Utah [abs.]: Mining Eng., v. 20 (8), p. 28.

(Continued on next page)

(Continued from preceding page)

STACEY, J. S., R. E. Zartman and I. T. NKomo, 1968, A lead isotope study of galenas and selected feldspars from mining districts in Utah: Econ. Geology, v. 63 (7), p. 796-814, illus.

STEWART, J. H., 1969, Systematic pattern of tensional failure producing Basin and Range structure in Nevada and Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 78-79.

STOKES, W. L., 1968, Relation of fault trends and mineralization, eastern Great Basin, Utah: Econ. Geology, v. 63 (7), p. 751-759, illus.

STOKES, W. L., 1969, Scenes of the plateau lands and how they came to be, 66 p. (privately published).

STOKES, W. L., 1969, Stratigraphy of the Salt Lake region, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 36-49, illus.

STOKES, W. L., and J. Balsley, 1968, Supposed coprolites from the Ferron Sandstone of Utah [abs.]: Utah Acad. Sci., Arts and Letters Proc., v. 45 (1), p. 320.

STOKES, W. L., and others, 1969, The San Rafael group in the Lake Powell region, *in* Geology and natural history of the Grand Canyon region, Fifth Field Conference, Powell Centennial River Expedition: Four Corners Geol. Soc., p. 184-189, illus.

STONE, D. D., 1968, Desmoinesian conodonts from Utah, Colorado and Iowa [abs.]: Dissert. Abs., Sec. B, Sci. and Eng., v. 29 (4), p. 1410B-1411B.

STRAESSER, M., 1968, Der Grosse Salzsee Nordamerikas [with English abs.]: Erdkunde, v. 22 (4), p. 284-294, illus.

SUMSION, C. T., 1969, Groundwater occurrence in the Spanish Valley area, Grand and San Juan counties, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 79-80.

TAYLOR, M. E., 1969, Biostratigraphy and environments of Upper Cambrian (upper Franconian-Trempealeauan) strata in the central Great Basin, Utah and Nevada [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 81.

TEMPLE, D. C., 1969, Mount Ogden granite: M. S. thesis, Univ. of Utah.

TERRELL, F. M., 1969, Silicified trilobite zonation in the lower Fillmore Formation in western Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 82.

THOMSON, K. S., and P. P. Vaughn, 1968, Vertebral structure in Rhipidistia (Osteichthyes, Crossopterygii) with description of a new Permian genus: Postilla, No. 127, 19 p., illus.

TIDWELL, W. D., S. R. Rushforth and A. D. Simper Jr., 1969, Lepidodendrales from the Manning Canyon Shale Formation, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 82.

TIDWELL, W. D., S. R. Rushforth, J. L. Reveal and H. Behunin, 1969, Petrified palm wood from the Arapien Shale (Jurassic) of Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 82-83.

TOOKER, E. W., and R. J. Roberts, 1969, Thrust fault structures in the Stansbury Mountains, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 83.

U. S. GEOL. SURVEY, 1969, Canyonlands National Park and vicinity, Utah: National Park Map.

VAN DE GRAAFF, F. R., 1969, Depositional environments and petrology of the Castlegate Sandstone (Cretaceous), east-central Utah [abs.]: Dissert. Abs. Int., v. 30 (4), p. 1760B.

VAN DORSTON, P. L., 1969, Environmental analysis of the Swan Peak Formation in the Bear River Range, north-central Utah and southern Idaho [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 84.

WANG, Y. F., 1969, Recognition of thrusting in the Gibson Mountains, Juab County, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 87-88.

WEISS, M. P., 1969, Oncolites, paleontology, and Laramide tectonics, central Utah: Am. Assoc. Petrol. Geol. Bull., v. 53 (5), p. 1105-1120, illus.

WHELAN, J. A., 1969, Geochronology of some Utah rocks, *in* Guidebook of northern Utah: Utah Geol. and Mineralog. Survey Bull. 82, p. 97-104.

WHELAN, J. A., 1969, Report on an examination of mines in Davenport Canyon: Deseret Peak mine and properties of Davenport Canyon Mines, Inc.: Utah Geol. and Mineralog. Survey Report 39, 12 p.

WHELAN, J. A., 1969, Subsurface brines and soluble salts of subsurface sediments, Sevier Lake, Millard County, Utah: Utah Geol. and Mineralog. Survey Spec. Studies 30, 13 p.

WHITE, T. E., 1968. Dinosaurs at home: New York, Vantage Press, 232 p., illus.

WILLIAMS, P. L., compiler, 1969, Map, Geology, structure and uranium deposits of the Moab quadrangle, Colorado and Utah, 1964. Reprinted. Scale 1:250,000; two sheets (geology, and structure and uranium deposits): U. S. Geol. Survey Miscellaneous Geologic Investigations Map L-360.

WILLIAMS, J. S., A. R. Southard, J. H. Milligan and P. Summers, 1969, Surficial geology of the Mount Pisgah quadrangle, Box Elder and Cache counties, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 89.

WILSON, J. C., 1969, Ore-magma relation at Bingham, Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 90.

WOOD, H. B., 1968, Geology and exploitation of uranium deposits in the Lisbon Valley area, Utah, *in* Ore deposits of the United States, 1933-1967: Graton-Sales v. 1, New York, Am. Inst. Mining, Metall. and Petroleum Engineers, p. 770-789, illus.

WOODWARD, L. A., 1969, Large-scale tectonic bedding associated with major thrust plate, western Utah [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mtn. Sec.), p. 91.

WOODWARD, L. A., and M. J. O'Neill, 1969, Precambrian carbonate rocks of the Pilot Range, Nevada and Utah, and their regional significance [abs.]: Geol. Soc. Amer. Abs., pt. 5 (Rocky Mnt. Sec.), p. 91-92.

YOCHELSON, E. L., and C. R. Jones, 1968, *Telichispira*, a new Early Ordovician gastropod genus: U. S. Geol. Survey Prof. Paper 613-B, p. B1-B15, illus.

ZIETZ, I., P. C. Bateman, J. E. Case and others, 1969, Aeromagnetic investigation of crustal structure for a strip across the western United States: Geol. Soc. Amer. Bull., v. 80 (9), p. 1703-1714, maps.

ZOHDY, A. A. R., and D. B. Jackson, Electrical sounding profile east of the Jordan Narrows, Utah, *in* Geological Survey Research 1969, Chap. C: U. S. Geol. Survey Prof. Paper 650-C, p. C83-C88, illus.

SUBJECT INDEX

ABSOLUTE AGE

Age and temperature of Mule Ear diatreme: C. W. Naeser.

Chemical variations and K-Ar ages of volcanic rocks in Bull Valley district: H. R. Blank.

Chronology of intrusion, volcanism and ore deposition at Bingham: W. J. Moore.

Chronology of intrusion, volcanism and ore deposition at Bingham: J. Gilluly.

Geochronology of the eastern Basin and Range province and Colorado plateau: R. L. Armstrong.

Geochronology of Utah Rocks: J. A. Whelan.

Geologic evolution of Precambrian rocks: K. C. Condie.

Isotopic ages of Colorado Plateau mineral deposits: R. L. Mauger.

Lead isotope study of galenas and feldspars from mining districts in Utah: J. S. Stacey.

Mica peridotite, wyomingite and associated potassic igneous rocks: M. G. Best.

Ore emplacement, Kane Springs Canyon: D. M. Davidson Jr.

Palynology of Spotten Cave: J. R. Bushman.

Precambrian geochronology of northwest Uncompahgre Plateau: C. E. Hedge.

Radiocarbon measurements: R. M. Chatters.

AREAL GEOLOGY

Dinosaurs: T. E. White.

Field trip road log—Great Salt Lake and Antelope Island: T. Arnow.

Field trip road logs—Tintic mining district: T. S. Lovering.

Field trip road log—Willard thrust, Utah: A. J. Eardley.

Geologic story of Uinta Mountains: W. R. Hansen.

(Continued on next page)

(Continued from preceding page)

Geology of Bingham mining district: W. H. Smith.

Geology and natural history of Grand Canyon: D. L. Baars, ed.

Geology and mineralogy of Milford Flat and Old Moscow Mine, Utah: M. S. Abou-Zied.

Geology of southern Sevier Plateau: P. D. Rowley.

Guidebook of northern Utah: M. L. Jensen, ed.

Relation and history of structures eastern Great Basin: R. B. Nelson.

Surficial geology of Mounta Pisgah quadrangle: J. Williams.

ECONOMIC GEOLOGY

Bingham district–Zoned porphyry ore deposit: A. James.

Black gold in Utah's Circle Cliffs?: H. R. Ritzma.

Determination of oil shale potential, Green River Formation: H. R. Ritzma.

Developments in Four Corners-Intermountain area in 1968: D. L. Reese.

Exploration targets for uranium deposits: D. R. Shawe.

Fault trends and mineralization, eastern Great Basin: W. L. Stokes.

Geologic map, Causey Dam quadrangle: T. E. Mullens.

Geologic mapping techniques at Kennecott's open pit mine at Bingham Canyon: W. H. Smith.

Geology of Bingham mining district: W. H. Smith.

Geology, ore deposits of East Tintic mining district: W. M. Shepard.

Geology, exploitation of uranium deposits in the Lisbon Valley area, Utah: H. B. Wood.

Geology mineralogy of Milford Flat and Old Moscow mine, Utah: M. S. Abou-Zied.

Geology of Spor Mountain beryllium district: D. R. Shawe.

Geology, ore deposits of Tintic mining districts: Kennecott Copper Corporation.

Geology, structure, uranium deposits of Moab quadrangle: P. L. Williams.

Geothermal power resources in Southwest: H. C. Birdseye.

Grosse Salzsee Nordamerikas: M. Straesser.

Hypothetical diagrams of porphyry copper deposits: A. H. James.

Igneous rocks, hydrothermal alteration at Bingham: R. E. Bray.

Influence of channel deposits on Upper Cretaceous sedimentation and coal mining: J. D. Howard.

Iron deposits of Iron Springs district: J. H. Mackin.

Marysvale uranium deposits: P. F. Kerr.

Micromineralogy of galena ores, Burgin mine, East Tintic district: A. S. Radtke.

Mineral deposits, igneous activity in Park City, Tintic and Bingham districts: R. L. Mauger.

Mineral resources, San Juan County, Petroleum, potash, groundwater and miscellaneous minerals: H. R. Ritzma.

Mineral resources, San Juan County, uranium: H. Doelling.

Nonporphyry ores of Bingham district: R. D. Rubright.

Oil-impregnated sandstones, Dirty Devil, Colorado and Green rivers: J. L. Bowman.

Ore deposits of Park City mining district: A. J. Erickson, Jr.

Ore deposits of Park City district: M. P. Barnes.

Ore deposits of western Utah, eastern and central Nevada: H. P. Hewitt.

Ore emplacement, associated features, Kane Springs Canyon: D. M. Davidson.

Ore-magma relation at Bingham: J. C. Wilson.

Pennsylvanian evaporite-carbonate cycles, southern Rocky Mountains: J. A. Peterson.

Petroleum potential of Utah: H. R. Ritzma.

Report of mines in Davenport Canyon: J. A. Whelan.

Salt deposits of Paradox basin: R. J. Hite.

Stratigraphy of Star Range: G. B. Baetcke.

Tintic mining district: H. T. Morris.

Upper Valley oil field: J. A. Campbell.

Uranium, copper mineralization in Big Indian Wash-Lisbon Valley mining district: L. J. Schmitt.

Uranium in Utah: R. E. Cohenour.

Uranium mining industry, Monument Valley and White Canyon district: R. C. Malan.

ENGINEERING GEOLOGY

Engineering geology of northern Utah landslides: W. T. Parry.

Landslides of Utah: J. F. Shroder.

Pre-slip rotational strains in unstable slopes: A. Nicol.

Shatter cones at TNT explosion craters: D. J. Roddy.

Silver Lake Flats dam and reservoir site: J. L. Holland.

GEOCHEMISTRY

Chemical variations and K-Ar ages of volcanic rocks: Bull Valley district: H. R. Blank.

Chloride fall-out in Great Salt Lake watershed: A. J. Eardley.

Eutrophication trends of Bear Lake, Idaho-Utah: D. Nyquist.

Geochemical study, Alta and Clayton Peak intrusives: C. B. Belt, Jr.

Gold-bearing jasperoid in Drum Mountains: J. H. McCarthy, Jr.

Isotope geochemistry of strontium in Great Salt Lake: L. M. Jones.

Stable isotopes and origin of uranium deposits of Utah: M. L. Jensen.

Isotopic sulfur and hydrogen in petroleum: R. G. Pankina.

Lead isotope study of galenas and feldspars from mining districts in Utah: J. S. Stacey.

Micromineralogy of galena ores, Burgin mine, East Tintic district: A. S. Radtke.

0-18:0-16 and C-13:C-12 ratios in hydrothermally dolomitized limestones, manganese carbonate replacement ores of Drum Mountains: T. S. Lovering.

Petrology and trace element chemistry of Carmel Formation: A. G. Everett.

Subsurface brines and salts of subsurface sediments, Sevier Lake: J. A. Whelan.

GEOMORPHOLOGY

Geologic history of Colorado River; C. B. Hunt.

Geology and structure of Stansbury Island: F. W. P. Chapusa.

Geology of Uinta Mountains: J. B. Lindsay.

Gravitational gliding in Flagstaff Formation: M. T. Moussa.

Grosse Salzsee Nordamerikas: M. Straesser.

Isotopic data on fumaroles of Italian volcanoes: J. Cheminee.

Mount Ogden granite: D. C. Temple.

Origin of Meander anticline, Cataract Canyon: F. E. Mutschler.

Parunuweap Formation: W. M. Dalness.

Plateau lands: W. L. Stokes.

Structures of Rocky Mountains, Colorado and Utah: A. J. Eardley.

Tertiary drainage development across Uinta Mountains: W. R. Hansen.

Thaynes Formation: H. P. Smith.

(Continued on next page)

(Continued from preceding page)

GEOPHYSICAL SURVEYS

Bottom gravity meter survey of Great Salt Lake, Utah: K. L. Cook.

Crustal structure across the western United States: I. Zietz.

Electrical sounding profile east of Jordan Narrows: A. A. R. Zohdy.

Heat flow temperature measurements in boreholes: J. K. Costain.

Regional gravity survey, Kaiparowits region, Saugunt fault: R. C. Fox.

Regional gravity survey , Millard, Juab and Sevier counties: W. F. Isherwood.

Residual analysis of field data over structures in Utah and Colorado: C. D. Buttgereit.

Seismic-refraction profiles: R. E. Mattick.

Sub-bottom seismic profile, Promontory Point to Lakeside, Great Salt Lake: R. B. Smith.

Thermal springs near Midway: C. H. Baker, Jr.

Thrusting in northwestern Utah: K. L. Cook.

GRAVITY SURVEYS

Bottom gravity meter survey of Great Salt Lake: K. L. Cook.

Gravity and magnetic surveys of Grouse Creek and Raft River Mountains: M. M. M. Khattab.

Gravity survey, Millard, Juab and Sevier counties: W. F. Isherwood.

Gravity survey, Kaiparowits region, Saugunt fault: R. C. Fox.

HYDROGEOLOGY

Chloride fall-out in Great Salt Lake watershed: A. J. Eardley.

Electric analog model in water-resources investigation: R. W. Mower.

Geochemistry and hydrodynamics of Paradox Basin: B. B. Hanshaw.

Ground-water discharge toward Great Salt Lake: R. W. Mower.

Groundwater hydrology of Jordan Valley: R. W. Mower.

Ground-water hydrology of southern Cache valley: L. P. Beer.

Groundwater occurrence in Spanish Valley: C. T. Sumsion.

Hot pots near Midway: C. H. Baker, Jr.

Hydrology and chemistry of Great Salt Lake: R. J. Madison.

Mineral resources, San Juan County, groundwater and miscellaneous minerals: H. R. Ritzma.

Navajo Sandstone as an aquifer: H. D. Goode.

Regional hydrogeology of Navajo and Hopi Indian reservations: M. E. Cooley.

Thermal springs near Midway: C. H. Baker, Jr.

Tracing ground-water movements in Uinta Mountains: R. E. Marsell.

MAPS

Canyonlands National Park and vicinity: map.

Charting Laramide structures of western Utah: A. J. Eardley.

Fault trends and mineralization, eastern Great Basin: W. L. Stokes.

Geochemical study, Alta and Clayton Peak intrusives: C. B. Belt, Jr.

Geologic evolution of Precambrian rocks, northern Utah: K. C. Condie.

Geologic map, Causey Dam quadrangle: T. E. Mullens.

Geologic map, Columbia area, Carbon and Emery counties: F. W. Osterwald.

Geology of Desert Mountain intrusives: D. F. Kattelman.

Groundwater hydrology of Jordan Valley: R. W. Mower.

Hydrogeology of Navajo and Hopi Indian reservations: M. E. Cooley.

Oil shale potential, Green River Formation: H. R. Ritzma.

Radial movements, western Wyoming salient of Cordilleran overthrust belt: G. W. Crosby.

MINERALOGY

Billingsleyite, new silver sulfosalt: C. Frondel.

Micromineralogy of galena ores, Burgin mine, East Tintic district: A. S. Radtke.

Mineralogy and physical properties of clays in cordilleran landslides: E. C. Booy.

Order-disorder in coexisting plagioclase and alkali feldspar from Mineral Range: L. J. Herber.

Origin of pyrophyllite-rectorite in shales of north central Utah: G. V. Henderson.

Phosphate mineralogy with electron probe: C. W. Mead.

Utah oddities : H. H. Doelling.

PALEOMAGNETISM

Paleomagnetic evidence for time-transgressive lithologic units, Moenkopi Formation: C. E. Helsley.

Paleomagnetism in Mesaverde group: D. E. Kilbourne.

PALEONTOLOGY

Ammonoids from lower Desert limestone, northern Stansbury Mountains: M. S. Petersen.

Annelids from Middle Cambrian Spence shale of Utah: R. A. Robison.

Antiacodont from Green River Eocene: J. J. Burke.

Brachiopods from upper Garden City Formation: R. J. Ross, Jr.

Carboniferous trilobites: C. K. Chamberlain.

Conodont fauna, Notch Peak Limestone, House Range: J. F. Miller.

Desmoinesian conodonts from Utah, Colorado and Iowa: D. D. Stone.

Dinosaurs: T. E. White.

Echinoderm from Middle Cambrian of Utah: R. A. Robison.

Fossil tracks from Green River Formation: M. T. Moussa.

Graveyard of prehistoric monsters: B. C. Cushing.

Late Cretaceous Ammonites, Scaphites in western U. S.: W. A. Cobban.

Late Ordovician and Silurian coral communities, eastern Great Basin: D. R. Budge.

Lepidodendrales from Manning Canyon Shale Formation: W. D. Tidwell.

Middle Cambrian fossils, northern Utah: R. A. Robison.

Middle Cambrian hexactinellid sponge from western Utah: J. K. Rigby.

Oncolites, paleontology and Laramide tectonics, central Utah: M. P. Weiss.

Origin of fossiliferous concretions in Ferron sandstone: J. K. Balsley.

Paleontology, paleoecology of Curtis Formation: R. D. Hoggan.

Palynology of Kaiparowits Formation: C. F. Lohrengel.

Palynology of Spotten Cave: J. R. Bushman.

Petrified palm wood from Arapien Shale: W. D. Tidwell.

Prehistoric man in Utah: J. P. Marwitt.

Silicified trilobite zonation in lower Fillmore Formation in western Utah: F. M. Terrell.

Telichispira, Early Ordovician gastropod genus: E. L. Yochelson.

Dinosaurs: J. H. Madsen, Jr.

Triassic echinoids of North America: P. M. Kier.

Vertebral structure in Rhipidistia (Osteichthys, Crossopterygii): K. S. Thomson.

PETROLOGY

Biostratigraphy and environments of Upper Cambrian strata in central Great Basin: M. E. Taylor.

(Continued on next page)

(Continued from preceding page)

Breccia structures in Ontario mine, Park City district: W. J. Garmoe.

Cambrian algal biostromes and regional dolomitization in Great Basin: J. Kepper.

Channel deposits, Upper Cretaceous sedimentation: J. D. Howard.

Chemical variations, K-Ar ages in the Bull Valley district: H. R. Blank.

Coprolites, Ferron Sandstone: W. L. Stokes.

Delta facies, Green River Formation: A. F. Jacob.

Depositional environments, petrology of Castlegate Sandstone: F. R. Van De Graaff.

Geochemical study, Alta and Clayton Peak intrusives: C. B. Belt, Jr.

Geologic evolution of Precambrian rocks, northern Utah: K. C. Condie.

Geology of Desert Mountain intrusives: D. F. Kattelman.

Identification, interpretation of Upper Cretaceous fluvial, deltaic sandstones: E. Cotter.

Igneous rocks in Bingham mining district: W. J. Moore.

Kimberlite-bearing breccia in Moses Rock dike: T. R. McGetchin.

Oncolites, paleontology and Laramide tectonics of central Utah: M. P. Weiss.

Ore-magma relation at Bingham: J. C. Wilson.

Origin of calcareous oolites: R. M. Mitterer.

Palynomorphs as sedimentation indicators, Straight Cliffs sandstone: R. Orlansky.

Permian and Lower Triassic transition, Grand Canyon: H. J. Bissell.

Petrofrabics of mafic and ultramafic inclusions from kimberlite pipes: H. Helmstaedt.

Petrographic analysis of Atokan carbonate rocks: M. Rich.

Petrographic and statistical study, Pennsylvanian Honaker Trail Formation: F. Demirmen.

Petrology of Gartra member, Uinta Mountains: C. D. McCormick.

Petrology and geochemistry, Meade Park member of Phosphoria Formation: P. J. Cook.

Petrology and trace element chemistry of Carmel Formation, Iron Springs mining district: A. G. Everett.

Sedimentary cycles, Green River Formation: L. R. High, Jr.

Sedimentary structures from flash floods: M. D. Picard.

Sill-laccolith-bysmalith, Henry Mountains: D. D. Pollard.

Source and emplacement of kimberlite at Moses Rock dike: T. R. McGetchin.

Stratigraphic variations, Navajo Sandstone: J. E. Marzolf.

Swan Peak Formation in Bear River Range: P. L. VanDorston.

STRATIGRAPHY

Age and significance of conglomerate, Newfoundland and Silver Island Mountains: R. J. Roberts.

Biostratigraphy and environments of Upper Cambrian in central Great Basin: M. E. Taylor.

Catalog: Library samples for geological research.

Conodonts, Notch Peak Limestone, House Range: J. F. Miller.

Delta facies, Green River Formation: A. F. Jacob.

Environmental analysis, Swan Peak Formation, Bear River Range: P. L. VanDorston.

Four Upper Cretaceous Straight Cliffs Formation in Kaiparowits region: F. Peterson.

Geologic map, Causey Dam quadrangle: T. E. Mullens.

Geology of southern Sevier Plateau: P. D. Rowley.

Geology, structure, uranium deposits of Moab quadrangle: P. L. Williams.

Green River Formation, Soldier Summit: M. T. Moussa.

Kaiparowits and Black Mesa basins: R. H. Lessentine.

Lexicon stratigraphic names, northern Arizona and southern Utah: C. M. Molenaar.

Moenkopi group, north-central Utah: H. P. Smith.

Oncolites, paleontology, and Laramide tectonics, central Utah: M. P. Weiss.

Paleoecology, Green River Formation: J. L. Baer.

Paleontology, paleoecology of Curtis Formation: R. D. Hoggan.

Paleozoic rocks of Grand Canyon: E. D. McKee.

Petrographic analysis of Atokan carbonate rocks, central and southern Great Basin: M. Rich.

Precambrian carbonate rocks, Pilot Range: L. A. Woodward.

Regional stratigraphic variations, Navajo Sandstone: J. E. Marzolf.

Regional stratigraphy of Paradox Basin: J. A. Peterson.

San Rafael group, Lake Powell: W. L. Stokes.

Significance palynomorphs, sedimentation indicators in Cretaceous Straight Cliffs sandstone: R. Orlansky.

Silicified trilobite zonation, Fillmore Formation: F. M. Terrell.

Stratigraphy, Chinle and Moenkopi formations, Navajo and Hopi reservations: C. A. Repenning.

Stratigraphy, conodont zonation of type Leatham Formation, Bear River Range: C. A. Sandberg.

Stratigraphy and economic significance, Currant Creek Formation: R. F. Garvin.

Stratigraphy of Salt Lake region: W. L. Stokes.

Stratigraphy of Star Range: G. B. Baetcke.

Structure and stratigraphy of Stansbury Island: D. E. Palmer.

Upper Cretaceous fluvial and deltaic sandstones: E. Cotter.

STRUCTURAL GEOLOGY

Conglomerate, Newfoundland and Silver Island Mountains: R. J. Roberts.

Cretaceous age of Willard Thrust: T. E. Mullens.

Deformation during sill and laccolith formation: D. D. Pollard.

Faults in Wasatch Range: L. F. Hintze.

Field trip road log—Willard thrust: A. J. Eardley.

Laramide structures of western Utah: A. J. Eardley.

Meander anticline, Cataract Canyon: F. E. Mutschler.

Nevadan folded system of southern Cordillera: Y. N. Melankholina.

Oncolites, paleontology and Laramide tectonics: M. P. Weiss.

Radial movements in western Wyoming salient, Cordilleran overthrust belt: G. W. Crosby.

Sevier orogenic belt and Uinta structures near Salt Lake City: M. D. Crittenden, Jr.

Strain measurements near Wasatch fault: K. L. Cook.

Structural geology of southern Pilot range: J. M. O'Neill.

Structure and history of salt anticline, Paradox Basin: E. M. Shoemaker.

Structure and stratigraphy of Stansbury Island: D. E. Palmer.

Structures in sedimentary, eastern Great Basin: R. B. Nelson.

Systematic pattern of tensional failure producing Basin and Range structure in Nevada and Utah: J. H. Steward.

Tectonic bending of major thrust plate, western Utah: L. A. Woodward.

(Continued on next page)

(Continued from preceding page)

Thrust fault structures in Stansbury Mountains: E. W. Tooker.

Thrusting in Gibson Mountains: Y. F. Wang.

Thrusting in northwest Utah: R. R. Compton.

Thrusting in northwestern Utah indicated by gravity and magnetic surveys: K. L. Cook.

Tintic Valley thrust and associated low-angle faults, central Utah: H. T. Morris.

Upheaval Dome, Paradox Basin: R. B. Mattox.

Wasatch fault zone, north central Utah: R. E. Marsell.

Willard thrust and Cache uplift: A. J. Eardley.

GOLD HILL BULLETIN OUT

The Gold Hill area in western Utah is the subject of the latest publication of the Utah Geological and Mineralogical Survey. Bulletin 83, *Mineralization in the Gold Hill Mining District, Tooele County, Utah,* describes one of the oldest mining sites in the state. Its history, from 1857 when travellers on the way to California through Overland Canyon stayed to look for minerals, is one of rapid mining development with a short-lived boom about 1917. Publication of geologic studies of the area started in 1892.

Sediments from Lower Cambrian through Lower Triassic comprise a relatively complete stratigraphic sequence. Tertiary pyroclastics intrude the older sediments.

Evaluation of the mineral potential shows most minerals occur in quantities too small for commercial production. The area, however, does contain impressive quantities of tungsten and low-grade beryllium ores, and large quantities of arsenic were produced during World War II.

Bulletin 83, by H. M. El-Shatoury and J. A. Whelan, arises from a doctoral dissertation by E.-Shatoury. Whelan, staff member of UGMS, supervised the research and assisted in preparation of the manuscript for publication.

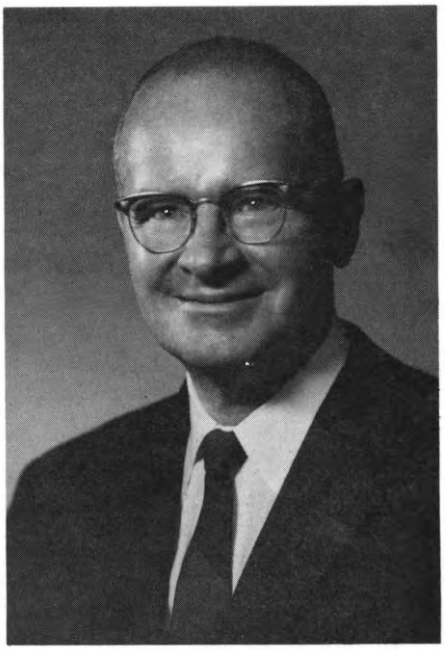
Bulletin 83 is for sale at the Utah Geological and Minerlogical Survey, 103 Utah Geological Survey Bldg., University of Utah, Salt Lake City 84112, for $2.25. Maps of the area, plans of most of the Gold Hill mine workings and analyses of ore samples are published in this bulletin.

UGMS Board Chairman Resigns

John M. Ehrhorn, Chairman of UGMS Advisory Board, is leaving Salt Lake City, and is resigning his position as chairman of the Board. He is retiring May 15 from his position of director of industrial development with U. S. Smelting, Mining and Refining Co., after 26 years with that company.

Mr. Ehrhorn plans to work at private consulting in Las Vegas.

UGMS hopes that Mr. Ehrhorn will be able to continue to be a member of its Advisory Board. His steady interest and constructive guidance during his term as chairman has been immensely valuable, and he will be missed.



John M. Ehrhorn

QUARTERLY REVIEW

State of Utah .....*Calvin L. Rampton Governor*
University of Utah .....*James C. Fletcher President*
College of Mines & Mineral Industries .....*George R. Hill Dean*
Utah Geological & Mineralogical Survey .....*William P. Hewitt Director*

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
103 Utah Geological Survey Building
University of Utah
Salt Lake City, Utah
84112

UTAH
GEOLOGICAL AND MINERALOGICAL SURVEY
103 Utah Geological Survey Building
THE UNIVERSITY OF UTAH
SALT LAKE CITY, UTAH 84112

Address correction requested

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