Biennial Report of the State Geologist for 1965-1967

THE GEOLOGICAL SURVEY OF WYOMING

Laramie, Wyoming

January, 1967

THE GEOLOGICAL SURVEY OF WYOMING
UNIVERSITY OF WYOMING
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LARAMIE, WYOMING 82070

January 10, 1967

The Honorable Stanley K. Hathaway
Governor of the State of Wyoming
Cheyenne, Wyoming.

Sir:

I have the honor to submit herewith the Biennial Report of the State Geologist covering the period July 1, 1965 to June 30, 1967, in accordance with the requirements of Article 11, Section 9-252, Wyoming Compiled Statutes, 1957.

Respectfully yours,

Horace D. Thomas

Horace D. Thomas
State Geologist

HDT:sa

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Cover: Mount Sniffel, elevation 11,500 feet, and the ghost town of Kirwin, in the Absaroka Mountains, Park County, Wyoming. Between 1902-07 this mining camp had a population estimated at 200 people, but little remains now to indicate the early day mining activity.

BIENNIAL REPORT OF THE STATE GEOLOGIST OF THE STATE OF WYOMING for 1965 - 1967

by

HORACE D. THOMAS

INTRODUCTION

This report covers the activities and accomplishments of the Geological Survey of Wyoming during the two-year period 1965-67. The geological projects undertaken are briefly described, the various activities of the Survey are discussed, and the resulting publications are listed.

ORGANIZATION OF THE GEOLOGICAL SURVEY

The Geological Survey of Wyoming was created in 1933 and has been located at the University of Wyoming since that time. Of the 47 state geological surveys, 32 are located at state universities or colleges, which suggests that most states recognize the advantages in affiliating the state geological survey with the department of geology at a state institution of higher learning.

Because of its university affiliation, it is possible for the Geological Survey of Wyoming to obtain the advice and part-time assistance of the nine geological specialists on the staff of the University Geology Department. The office of the Northern Rocky Mountains Branch of the U.S. Geological Survey is also located in Geology Hall and provides valuable assistance. Close collaboration is maintained with the University of Wyoming Natural Resources Research Institute, whose research is in part on the utilization of Wyoming mineral resources. The U.S. Bureau of Mines Laramie Petroleum Research Center is located nearby on the campus. The advice, suggestions, and assistance of engineers, chemists, physicists and other scientists on the campus are readily available.

In September, 1955, quarters in the new Geology Building on the campus were occupied. The Survey has four offices and a map and publication distribution room. In addition, a large part of the basement is devoted to storage space for oil well samples and cores. Most important, the Survey benefits from the availability of the modern technical equipment installed by the Department of Geology, such as X-ray diffraction equipment, differential thermal analysis equipment, magnetic separators, ultrasonic devices, and other equipment used in rock and mineral identifications.

Dr. S.H. Knight, Professor of Geology, served as State Geologist and Director of the Geological Survey of Wyoming from 1933 to 1940. The incumbent, Dr. H.D. Thomas, has served since March, 1941. By virtue of action by the University Administration, the State Geologist has a reduced teaching load so that a share of his time may be devoted to the direction of the Geological Survey.

In 1951, for the first time, a full-time Assistant State Geologist was employed. Dr. William H. Wilson resigned from the U.S. Geological Survey to accept the appointment. Dr. Wilson is the holder of five university degrees in geology and engineering and is a specialist in economic geology, engineering geology, and ground water geology. His addition to the staff aided immeasurably in broadening the program and services of the

State Geological Survey.

In September, 1963, Mr. Marvin L. Millgate was employed as a full-time geologist, but resigned recently to accept a position with the U.S. Bureau of Mines. A replacement is expected to be employed in the near future.

A full-time secretary, Mrs. Stephanie Aker, is also employed. Her duties involve the maintenance of office records, the distribution of publications and maps, and administration of non-technical office matters.

Students majoring in geology or taking post-graduate work constitute a valuable store of geological talent and are employed on a part-time basis as summer field geologists, to serve as geological draftsmen, to maintain collections of samples from wells drilled for oil or water, and in many other ways.

COMPARISON WITH OTHER STATES

The Geological Survey of Wyoming does not receive as large an appropriation as those received by most other state geological surveys. At present, 47 states have geological surveys. During 1963-64, the latest fiscal year for which figures are available, the 47 surveys had funds totaling $9,691,915 for geological research, services, and administration, or an average of about $200,000 per survey. This is four times the amount appropriated to the Geological Survey of Wyoming for the present fiscal year. Total funds available to the 47 geological surveys for all purposes (regulatory duties, federal matching monies, etc.) exceeded $14.7 million.

Although Wyoming ranks 10th among the states in valuation of mineral products ($502,000,000 in 1965), the State ranks 43rd among those appropriating funds for state geological surveys. The Illinois Geological Survey has over $1\frac{1}{4}$ million per year; 31 other surveys have between $900,000 and $100,000 per year, and 9 receive between $100,000 and $50,000 per year. Only the Connecticut, Vermont, South Carolina, Delaware, and New Hampshire surveys had less money than the Wyoming Geological Survey. These states rank low as mineral producers.

Most states, therefore, have much smaller mineral production valuations than Wyoming, yet appropriate a great deal more money for geological research than does our State. Furthermore, most of these do not have the potential for future mineral developments that Wyoming does.

The average number of full-time permanent technical personnel employed by each of the 47 geological surveys was 12. This compares with the 2.5 on the staff of the Geological Survey of Wyoming. Some of the geological staffs are surprisingly large: Illinois, 75; Michigan, 42; California, 37; Indiana, 31; and Kansas, 30. Some of the geological surveys of other western states have fair-sized staffs: New Mexico, 17; North Dakota, 15; Nebraska and South Dakota, 9 each, and Montana, 6.

AGRICULTURAL RESEARCH vs. GEOLOGICAL RESEARCH

Just as agricultural research may increase the valuation of Wyoming's annual agricultural products, so can geological research increase the valuation of our mineral production. It is of interest to note that our agricultural products during 1965 were valued at $183.2 million*, (apparently a record), whereas our mineral products were valued at $502 million, or more than three times as much. Vast sums of public money are spent each year in research in plant and animal pathology, agricultural chemistry, cereal and field

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* Cash receipts from farming and ranching, 1964-65: Wyo. Coop. Crop and Livestock Reporting Service, Wyo. Dept. Agric., 1966.

crops, forage and range, bee culture, wool, and other agricultural fields. The amount of public funds spent in Wyoming on geological research, if compared, would be a mere pittance.

DEPLETABLE MINERAL DEPOSITS AND THE FUTURE

It must be remembered that mineral deposits are depletable. What a catastrophe it would be if every oil well in Wyoming suddenly went dry and every ore body immediately played out! If our oil and gas production ceased, 10,000 employees, who are earning $53,000,000 per year, would move elsewhere. The $14,817,000 collected each year as property tax on oil and gas production would no longer accrue. We would greatly miss the effect of the $215,000,000 spent each year in the search for and the production of oil and gas and the manufacture of petroleum products. Nearly 37% of the State's ad valorem valuation would no longer exist. If all mining in the state were to cease, the result would be a similar economic disaster.

Fortunately, the exhaustion of our reserves of mineral fuels and nonmetallic and metallic minerals will not take place over night, but it is absolutely certain that every oil and gas well and every mine presently producing in the State will some day be abandoned.

It takes time to develop new mineral industries. Although trona was discovered in the Green River Basin in a well drilled in 1937, it was not until 1948 that the first trona was produced. Fourteen years passed before a second mine and plant went into operation in 1962. Even though the Atlantic City taconite deposit was mapped and described in 1949, it was not until 1962 that the first ore was shipped.

We must look to the future, therefore, and continue to study and evaluate our mineral resources if we are to find new deposits which may replace those presently being depleted.

NEED FOR A CONTINUING PROGRAM OF GEOLOGICAL INVESTIGATIONS

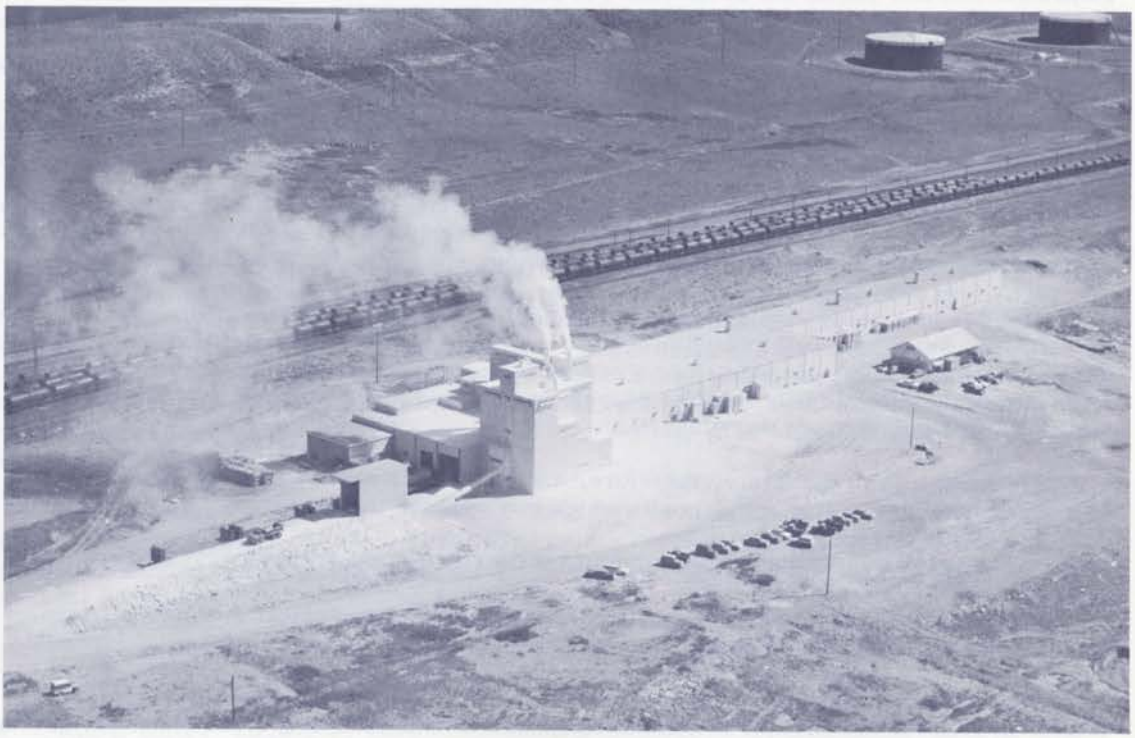
Four fundamental reasons for an intensive program of geological studies are given below; there are numerous others.

First, Wyoming is not competing on an equal basis with other states in geological research on mineral resources. A more comprehensive understanding of the economic geology of Wyoming is needed for the possible attraction of industry to the State and the development of these resources. The value of geological studies in attracting industry to Wyoming is exemplified by the recently completed $60,000,000 taconite ore plant of the United States Steel Corporation in the Atlantic City area. Although numerous state agencies have lent their aid to this development, the fact cannot be denied that the Atlantic City iron deposit first came to the attention of the United States Steel Corporation through a geological report issued jointly by the Geological Survey of Wyoming and the University of Wyoming Natural Resources Research Institute in 1949. Numerous other developments could be cited as having originated through previous geological studies.

Secondly, geological data are basic to the solution of Wyoming's water needs and usage. For instance, the development of ground water supplies cannot be attained without a proper understanding of the geology of the rocks in which the ground water occurs. Nor is it wise to construct a dam, large or small, unless geological studies indicate that the rocks at the dam site afford an adequate foundation for the structure and that geological conditions do not allow for subterranean leakage of water from the reservoir area. Geological studies provide knowledge regarding sources of construction materials: sand, gravel, and riprap for dams, bentonite for canal linings, and similar materials.

Thirdly, other State and municipal agencies are finding needs for more geological information and are seeking more and more data from us to help in the solution of problems in mineral availability, land classification, mineral leasing, foundation adequacy, road and highway construction and location, availability of water supplies, radioactive waste disposal, and even in game and fish culture.

Lastly, there is an increasing demand for geological information by rockhounds, tourists, and grade and high school pupils. A popular guide to the rocks and minerals of Wyoming, described later, was published during the biennium, and fills a real need. A related bulletin on fossils should be prepared. Semi-technical guides to the geology of the State parks and the major mountain ranges should be prepared. Requests from schools and individuals all over the country for Wyoming rock and mineral specimens are increasing daily.



The Big Horn Gypsum Company plant at Cody. This plant is designed to manufacture 100,000,000 square feet of wallboard per annum. Wyoming's gypsum reserves are essentially inexhaustible.

There is only one way in which the needed geological information can be obtained, and that is through technical investigations made in the field by competent geologists, and the only way geologists can operate effectively is under the supervision of experienced geologists - not under the aegis of nontechnical agencies - and with available laboratory and library facilities which are so necessary in modern geological studies.

In summary, the program of geological investigations now being carried on by the Geological Survey of Wyoming seems necessary and desirable. To maintain it at its present level would involve only a modest increase over the 1965-67 appropriation.

ACTIVITIES OF THE GEOLOGICAL SURVEY

TECHNICAL INVESTIGATIONS

Absaroka Mountains Project

The geologic mapping of the southern Absaroka Mountains was begun by Dr. W. H. Wilson in 1951. The total area mapped now approximates 900 square miles and has given detailed information on a region of essentially virgin geology. Nearly all the mapping, in country so rough that it can be covered adequately only on foot, has been done by Dr. Wilson, although an area of 30 square miles with an average relief exceeding 5,000 feet was mapped by Fred S. Fisher, graduate student, during the summers of 1963 and 1964, the major mineral resources being molybdenum and copper deposits.

As a result of the above work an exploration program for mineral deposits was initiated by a major mining company in one part of the area in 1961 and in another part in 1963. The same company conducted diamond drilling in the Kirwin area for copper, molybdenum, and silver during the four summers of 1963 - 1966.

As a follow-up of this project, diamond drilling for copper and molybdenum was undertaken by another major mining company in 1965 and 1966 in the Stinkingwater mineralized area.

Stinkingwater Peak and Copper Lake, Absaroka Mountains, Park County. These mountains are a massive accumulation of volcanic debris. Geological mapping in this high, rough country can be done only on foot.

In 1965, the U.S. Geological Survey made a reconnaissance study of the mineral resources of the Stratified Primitive Area. Since some of this area is within our Absaroka Mountains project area, the U.S. Geological Survey utilized much of our previously compiled data in preparing their Bulletin 1230-E, titled, "Mineral Resources of the Stratified Primitive Area, Wyoming".

The mapped area lies mainly within the Shoshone National Forest and in 1962 the U.S. Forest Service suggested that a guide to the geology of the area be prepared. The report was completed by W. H. Wilson in 1963 and has proved useful not only to the Forest Service but to tourists, hunters, fishermen, and backpackers visiting the area.

During the summer of 1966, John Dreier, a graduate student, carried on a petrologic and mineralogic study of part of the Sunlight Basin mineralized area in the Absaroka Mountains. This area is of significance in the exploration for copper deposits.

The following formal reports have resulted from this project:

Dunrud, C.R., 1962, Volcanic rocks of the Jack Creek area, southeastern Absaroka Range, Park County, Wyoming: 92 ms. p., 12 figs., 2 pls. (Graduate thesis).

Fisher, F.S., 1966, Tertiary intrusive rocks and mineralization in the Stinkingwater mining region: 137 ms. p., 26 pls., 2 tables. (Graduate thesis).

McGrew, A.R., 1965, Stratigraphy and mineralogy of the Blue Point member of the Wiggins formation, southeast Absaroka Range, Park County, Wyoming: 52 ms. p., 9 pls., 3 figs., 3 tables. (Graduate thesis).

Love, J.D., Wilson, W.H., Houston, R.S., and Simons, E.L., Dating of Eocene and Oligocene pyroclastic rocks near source areas in the southern part of the Absaroka Range, northwestern Wyoming: 23 ms. p., 2 tables, 6 figs. (To be published by the U.S. Geological Survey).

Wilson, W.H., 1960, Petrology of the Wood River area, southern Absaroka Mountains, Park County, Wyoming: 122 ms. p., 1 table, 16 figs., 2 pls.

_____, 1963, Correlation of volcanic units in the southern Absaroka Mountains, Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 2, No. 1, p. 13-20, 1 table, 3 pls.

_____, 1963, A guide to the geology of the Shoshone National Forest, Wyoming: 43 ms. p., 1 table, 16 figs., 1 pl.

_____, 1964, The Kirwin mineralized area, Park County, Wyoming: Geol. Surv. Wyo. Prelim. Rept. No. 2, 12 p., 1 table, 1 fig., 2 pls.

_____, 1964, Geological reconnaissance of the southern Absaroka Mountains, northwest Wyoming, Part I - The Wood River-Greybull River area: Contribs. to Geol., Univ. Wyo., Vol. 3, No. 2, p. 60-77, 1 table, 12 pls.

The following manuscripts are in preparation:

Dreier, John, Petrology and mineralization in the Sunlight Basin area, Park Co., Wyoming.

Wilson, W.H., Geology of the Soapy Dale quadrangle, Hot Springs and Park Counties, Wyoming. (To be published as a Geological Survey of Wyoming Bulletin).

Wilson, W. H., Geologic reconnaissance of the southern Absaroka Mountains, northwest Wyoming: Part II - Structure of volcanic sediments in the Wood River area. (To be published in Contributions to Geology).

Wilson, W. H., and Dunrud, C. R., Geology of the Irish Rock quadrangle, Park County, Wyoming. (To be published as a Geological Survey of Wyoming Bulletin).

Diamond drilling for copper and molybdenum in the Kirwin mineralized area, Absaroka Mountains, northwestern Wyoming.

Hartville Project

The geology of parts of the Hartville uplift of east-central Wyoming was studied by Marvin L. Millgate.

Haystack Range. - The Precambrian rocks of the Haystack Range have been studied over an area of 52 square miles and their distribution and attitude have been delineated on a map with a scale of 1:24,000. A published report resulting from this project is titled as follows:

Millgate, Marvin L., 1965, The Haystack Range, Goshen and Platte Counties, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 5, 12 p., 1 pl.

Rawhide Buttes area. - During the 1964 field season Mr. Millgate completely mapped the geology of the Rawhide Buttes area on a scale of 1:12,000. The area is principally one of Precambrian rocks, although Paleozoic rocks occupy part of it. The final map is now

being drafted and the manuscript is being processed for early publication as a Preliminary Report.

Copper Mountain Project

Copper Mountain is located a few miles east of Wind River Canyon, north of Shoshoni, Fremont County, central Wyoming. Little detailed geological work has been done in the Precambrian roeks of the area but there have been references to the occurrence of copper, tungsten, gold, beryl, lepidolite, columbite-tantalite and iron.

In 1960, J.P. Gliozzi, under a Geological Survey of Wyoming subsidy, began the mapping of the Guffy Peak quadrangle. Additional field work was done intermittently. Thirty-five square miles were mapped and the final report, which will constitute a doctoral thesis, is now being prepared.

In 1965, Mr. Millgate spent a long field season in the study of iron formation. Detailed mapping covered $5\frac{1}{2}$ square miles, a section of iron formation was measured, and 23 assays of samples were made. The map has been drafted and the manuscript is being processed for publication.

The two studies indicate that layers of iron formation, some running as high as 31% Fe occur throughout and beyond the areas studied. One layer is as thick as 75 feet.

Precambrian Project

The Precambrian project, which involved the mapping of the crystalline cores of the mountain ranges, was initiated in July, 1957.

Medicine Bow Mountains. - The first phase of the program, the mapping of the Medicine Bow Mountains, has been completed. This work was done by 11 graduate students at the University of Wyoming and by Dr. R.S. Houston, Professor of Geology, who also directed the program. Mapping covered approximately 41 townships, or about 1,500 square miles. The scale of the mapping ranged from 600 feet to the inch to 2,200 feet to the inch, depending on structure, rock type, and exposures. A number of areas of economic interest were studied, including pegmatites in the southern part of the mountains, vermiculite on the western slope, copper-gold deposits in the Keystone and Gold Hill districts, magnetite deposits in the Lake Owen area, sulfide-facies iron formation in the central part of the mountains and scattered nonmetallic deposits of possible economic interest.

In addition to the regional mapping and the study of mineral deposits, the geologic study of the Medicine Bow Mountains has been especially valuable in demonstrating the relationship between structural features of Precambrian age and those of younger age that are of interest to the petroleum geologist. A complex Precambrian geologic history has been worked out and the region is well suited for correlation of field and geochronologic studies. Dr. Alan Hill, of the Lamont Geological Observatory, Columbia University, and Dr. Paul Gast, of Yale University, have cooperated in the project by dating the Precambrian rocks in years, using primarily whole-rock strontium-rubidium methods. They have shown that rocks older than 2.5 billion years are present in the northwestern part of the mountains, and the preliminary results indicate that the great line of crustal weakness, which Houston and McCallum have named the Mullen Creek-Nash Fork shear zone, that divides the mountains into two distinct geological parts, may be a major structural feature of this part of the Rocky Mountains. No rocks 2.5 billion years or older are found south of this shear zone.

The comprehensive publication on the geology of the Medicine Bow Mountains will soon appear. All drafting has been completed and the principal map, on a scale of one inch equals one mile will show geologic units by means of 65 different colors and color symbols. The manuscript is now being edited by a person employed for that purpose.

A number of other papers on various phases of the geology of the Medicine Bow Mountains have already appeared, as follows:

Currey, Donald R., 1965, The Keystone gold-copper prospect area, Albany County, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 2, 12 p., 1 table, 2 figs., 2 pls.

Hills, Alan, Gast, P.W., and Houston, R.S., 1964, Chronology of some Precambrian igneous and metamorphic events of the Medicine Bow Mountains, Wyoming (Abst.): Geol. Soc. America Program, 1964 Ann. Meeting.

Houston, R.S., 1961, Geology of the Big Creek pegmatite area, Carbon County, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 1, 11 p., 1 fig., 2 pls.

_____, 1963, Structure of Precambrian rocks of the Medicine Bow Mountains and its relationship to post-Pre-Cambrian structural patterns (Abst.): Am. Assoc. Petrol. Geol., Rocky Mt. Sec. Program, p. 18-19.

Houston, R.S., and McCallum, M.E., 1961, The Mullen Creek-Nash Fork shear zone, Medicine Bow Mountains, southeastern Wyoming (Abst.): Geol. Soc. America Special Paper 68, p. 91.

Houston, R.S., and Parker, R.B., 1963, Structural analysis of a folded quartzite, Medicine Bow Mountains, Wyoming: Bull. Geol. Soc. America, Vol. 74, p. 197-202.

King, John S., 1964, Cooper Hill - a gravity slide in the northeastern Medicine Bow Mountains, Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 3, No. 1, p. 33-37.

McCallum, M.E., 1962, Glaciation of Libby Creek Canyon, east flank of Medicine Bow Mountains, southeastern Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 1, No. 1, p. 21-30.

_____, 1964, Cataclastic migmatites of the Medicine Bow Mountains, Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 3, No. 2, p. 78-89.

_____, 1964, Dedolomitized marble lenses in shear-zone tectonites, Medicine Bow Mountains, Wyoming (Abst.), Geol. Soc. America Program, 1964 Ann. Meeting.

Swetnam, Monte, 1962, The origin of Precambrian crystalline rocks in the Pelton Creek area, Medicine Bow Mountains, Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 1, No. 1, p. 41-48.

A manuscript by F. Allan Hills (Yale), Paul W. Gast (Columbia), Ian G. Swainback (Columbia) and R.S. Houston (Wyoming) titled "Precambrian geochronology of the Medicine Bow Mountains of southeastern Wyoming" has been completed and submitted for publication in the Bulletin of the Geological Society of America. As a result of this work, the Precambrian rocks of the Medicine Bows will be more comprehensively dated than those of any other area in the Rocky Mountain region.

Eleven formal reports (graduate theses) have been completed for the Medicine Bow Mountains. These may be consulted at, or copies may be borrowed from, the Geology Library or the Geological Survey of Wyoming. Separate maps are available for sale to the public. The reports are as follows:

Childers, M.O., 1957, Geology of the French Creek area, Albany and Carbon Counties, Wyoming. (Covers 49 sq. mi., 58 ms.p.)

Currey, D.R., 1959, Geology of the Keystone area, Albany County, Wyoming. (Covers 45 sq. mi., 64 ms. p.)

King, James, R., 1962, Geology of the Boswell Creek area, Albany County, Wyoming. (Covers 30 sq. mi., 83 ms. p.)

King, John S., 1963, Petrology and structure of the Precambrian and post-Mississippian rocks of the northeastern Medicine Bow Mountains, Carbon County, Wyoming. (Covers 65 sq. mi., 125 ms. p.)

Matus, Irwin, 1958, Geology of the lower French Creek area, Carbon County, Wyoming. (Covers 28 sq. mi., 38 ms. p.)

McCallum, M.E., 1964, Petrology and structure of the Precambrian and post-Mississippian rocks of the east-central portion of the Medicine Bow Mountains, Albany and Carbon Counties, Wyoming. (Covers 110 sq. mi., 164 ms. p.)

Myers, W.G., 1958, Geology of the Sixmile Gap area, Albany and Carbon Counties, Wyoming. (Covers 18 sq. mi., 74 ms. p.)

Orback, C.J., 1960, Geology of the Fox Creek area, Albany County, Wyoming. (Covers 19 sq. mi., 100 ms. p.)

Ruehr, Ben, 1961, Geology of the Devils Gap area, Albany and Carbon Counties, Wyoming. (Covers 26 sq. mi., 48 ms. p.)

Stensrud, Howard L., 1963, Geology of the Lake Owens mafic complex, Albany County, Wyoming. (Covers 26 sq. mi., 46 ms. p.)

Swetnam, Monte, 1961, Geology of the Pelton Creek area, Carbon and Albany Counties, Wyoming. (Covers 23 sq. mi., 78 ms. p.)

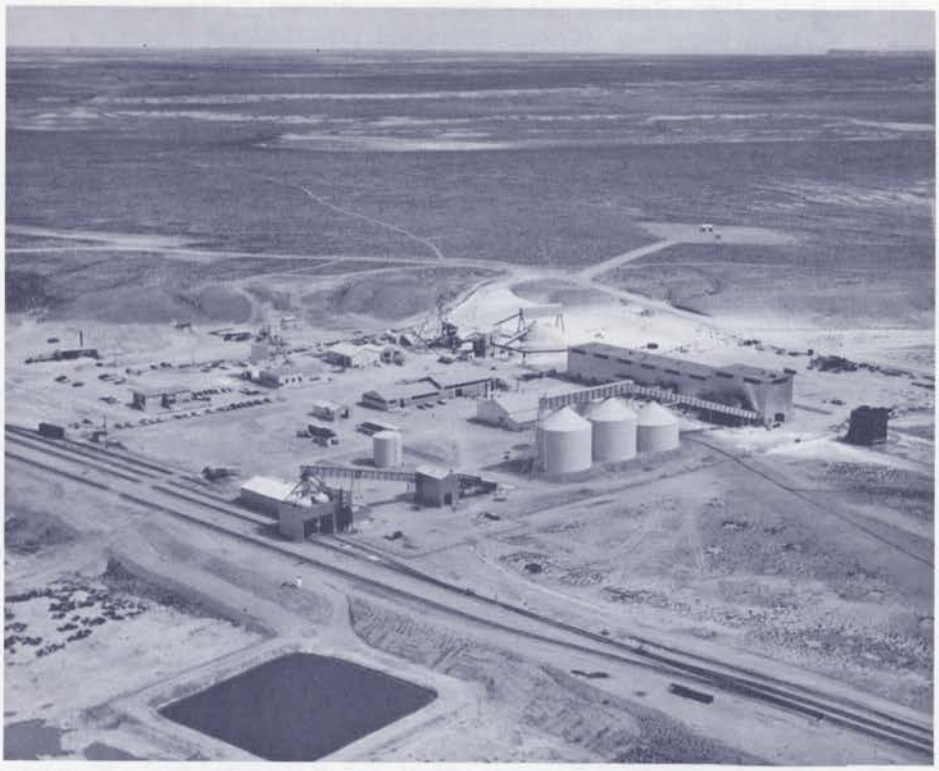
Manuscripts in preparation are listed below. These are extracts from more comprehensive reports, and are to be published as Preliminary Reports:

McCallum, Malcolm, Mineral deposits of the Centennial Ridge district, (gold, copper, platinum), Albany County, Wyoming. (Manuscript to be processed)

_____, The Rambler mining district (copper, platinum), Albany County, Wyoming. (Manuscript to be processed)

Stensrud, H., Magnetite occurrences in the Lake Owens mafic complex, Albany County, Wyoming. (Manuscript in preparation)

A series of geologic quadrangle maps has been compiled by Dr. Houston made up of the 28 quadrangles which cover the Medicine Bow Mountains. These maps are on a scale of $2\frac{1}{2}$ inches to 1 mile. The drafting is completed and the maps of areas of greatest geologic or economic interest will be printed in black and white.



Trona mine and plant of Stauffer Chemical Company of Wyoming which began operation in 1962. Trona yields a valuable industrial chemical known as soda ash.

Sierra Madre studies. - The mapping of the Precambrian rocks of mountain ranges other than the Medicine Bows is continuing. Approximately two-thirds of the Sierra Madre, a range in southern Carbon County, has been mapped in recent years. A compilation of all maps on a scale of one inch equals one mile, similar to the map of the Medicine Bow Mountains, will be assembled when all mapping is completed. No text is planned to accompany the map, but preliminary reports on specific areas of economic interest will be published. The following reports (graduate theses) have been completed and are available to the public:

Ferris, C.S., Jr., 1964, Petrology and structure of the Precambrian rocks southeast of Encampment, Wyoming. (Covers 29 sq. mi., 74 ms. p.)

Lackey, L.L., 1965, Petrography of metavolcanic rocks and granitic rocks of Precambrian age in the Huston Park area, Sierra Madre, Wyoming. (Covers 24 sq. mi., 78 ms. p.)

Merry, Raymond J., 1963, Precambrian geology, shear zones, and associated mineral deposits of the Hog Park area, Carbon County, Wyoming. (Covers 30 sq. mi., 73 ms.p.)

Short, B.L., 1958, A geologic and petrographic study of the Ferris-Haggerty mining area, Carbon County, Wyoming. (Covers 10 sq. mi., 138 ms. p.)

Wied, O. J., 1960, Geology of the Encampment area, Carbon County, Wyoming. (Covers 36 sq. mi., 52 ms. p.)

Field work has been completed on the following projects in the Sierra Madre:

DeNault, Kenneth, Lead and zinc in the Broadway Claims, southeastern Sierra Madre, Carbon County, Wyoming. (Covers 18 sq. mi., field work completed summer 1966.)

Ebbett, Ballard, Metasedimentary rocks and copper deposits of the northern Sierra Madre, Carbon County, Wyoming. (Covers 104 sq. mi.). The map is completed and is on open file.

Wind River Mountains. - Geologic work in the Wind River Mountains is under the supervision of Dr. Ronald B. Parker in his position as Associate Professor of Geology. Two formal reports (graduate theses) have been completed, as follows:

Hodge, Dennis, 1963, Polymetamorphism of Precambrian rocks in the southwestern Wind River Mountains, Fremont County, Wyoming. (Covers 16 sq. mi., 49 ms. p.)

Worl, R.G., 1963, Superimposed deformations in Precambrian rocks near South Pass, Wyoming. (Covers 16 sq. mi., 53 ms. p.) A condensation of this report was published in Contribs. to Geol., Univ. Wyo., Vol. 2, No. 2, 1963, p. 109-116.

Union Pass area. - Union Pass lies at the north end of the Wind River Mountains. The geology is sufficiently diversified and complex to serve as the basis for a Ph. D. thesis, and R.G. Worl was given the assignment. During mapping in late 1964, a taconite deposit similar to that being mined by U. S. Steel at South Pass was discovered. At this time a 60-square mile area has been mapped, the taconite deposit studied and sampled, and all analytical work completed. The final report is nearing completion.

Laramie Mountains. - Geologic work in the Laramie Mountains is under the supervision of Dr. Parker. Two formal reports covering areas in the central part of the mountains have been completed as graduate theses, as follows:

Fields, E.D., 1963, Precambrian rocks of the Halleck Canyon area, Albany County, Wyoming. (Covers 18 sq. mi., 91 ms. p.)

Hodge, Dennis S., Petrology and structural geometry of the Precambrian rocks in the Bluegrass area, Albany County, Wyoming. (Covers 45 sq. mi., 135 ms. p.)

The following studies in the Laramie Mountains are being completed:

Bothner, Wallace A., The geology of the Cooney Hills, Platte County, Wyoming. All field work covering 20 square miles of Precambrian rocks has been completed. The final Ph. D. thesis will be completed before June, 1967.

Smith, Bruce D., Geology and geophysics of the McGill Ranch area, Albany County, Wyoming. Fourteen squre miles of Precambrian rocks were mapped geologically and a geophysical survey covering an additional 22 square miles has been completed. A final report serving as a Master's thesis is now in preparation.

Toogood, David J., Relationship between major and minor structures during repeated folding in the Precambrian basement of the Laramie Mountains, Wyoming. Some $11\frac{1}{2}$ square miles were mapped in detail. The final report, now being compiled, will serve as a Master's thesis.

Seminoe Mountains. - A project in the Seminoe Mountains has been completed and the final report compiled, titled as follows:

Bishop, D. T., 1964, Retrogressive metamorphism in the Seminoe Mountains, Carbon County, Wyoming. (Covers 27 sq. mi., 49 ms. p.)

Regional mapping, stratigraphy, and commodity studies

In 1961 an increased appropriation was made for wages for temporary summer geologists, and a program of regional mapping, stratigraphy, and commodity studies was initiated. Additional graduate students were employed to undertake mapping of areas in which the geology was poorly known, but which might contain nonmetallic mineral deposits or mineral fuels. The resulting maps are also useful in ground water studies and petroleum exploration. Other investigations were made of specific commodities.

A number of published papers have resulted from this program, as follows:

Davis, John C., 1963, Origin of the Mowry shale: Contribs. to Geol., Univ. Wyo., Vol. 2, No. 2, p. 135-146, 1 tab.

_____, 1965, Bentonite deposits of the Clay Spur district, Crook and Weston Counties, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 4, 17 p., 6 figs., 1 pl.

Ferris, Clinton, S., Jr., 1966, Structural analysis of Precambrian rocks southeast of Encampment, Wyoming: Contribs. to Geol. Univ. Wyo., Vol. 5, No. 1, p. 13-19, 3 figs., 4 pls.

Fisher, Frederick S., 1965, Genesis of Recent gypsum in Stinkingwater Mining District, Park County, Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 4, No. 2, p. 45-49, 4 figs.

Hodge, Dennis S., and Worl, Ronald D., 1965, Multiple metamorphic episodes near South Pass, Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 4, No. 2, p. 51-57, 3 figs., 2 pls.

Twenty-three formal reports have been completed as graduate theses in this program, and copies are located in the Geology Library and in the Geological Survey files where they are available to the public. Copies may also be borrowed on interlibrary loan. Maps or charts accompanying the reports may be purchased through the Geological Survey.

Economic geology. -

Bullock, James M., 1964, Gypsum deposits in the northwestern part of the Bighorn Basin, Park Co., Wyoming, 91 ms. p., 6 figs., 8 pls., 5 tables.

Davis, John C., 1963, Clay Spur bentonite district, Crook and Weston Counties, Wyoming, 79 ms. p., 4 figs., 7 pls., 7 tables.

Graveson, David H., 1966, Uranium distribution in granites of the Shirley and Pedro Mountains, Carbon County, Wyoming, 66 ms. p., 8 figs., 5 pls.

Max, Michael D., Gypsum deposits in the northeastern part of the Bighorn Basin, Big Horn County, Wyoming, 122 ms. p., 9 figs., 4 pls., 1 table.

Ground water geology. -

Burritt E. C., 1962, Ground water study of part of the southeastern Laramie Basin, Albany County, Wyoming, 160 ms. p., 5 figs., 1 pl., 17 tables.

Johnson, Franklin, 1962, Ground water geology of central Niobrara County, Wyoming, 62 ms. p., 4 figs., 7 pls., 4 tables.

Petrology. -

Tebbutt, Gordon E., 1964, Lithogenesis of a distinctive Permian carbonate fabric, Big Horn and Washakie Counties, Wyoming, 81 ms. p., 2 figs., 5 pls.

Regional and structural geology. -

Bragdon, Frederick F., 1965, The geology of Fish Spring Creek and adjacent areas, Lincoln and Sublette Counties, Wyoming, 98 ms. p., 11 pls.

Chadeayne, Dennis K., 1966, The geology of the Pass Creek Ridge, St. Marys, and Cedar Ridge anticlines, Carbon County, Wyoming, 87 ms. p., 2 figs., 6 pls., 3 tables.

Dickey, M. L., 1962, Geology of the Green Mountain-Whiskey Peak area, Fremont County, Wyoming, 85 ms. p., 8 pls., 1 table.

Fruchey, R. A., 1962, Overthrusting in the Mt. Thompson and adjacent areas, Sublette and Lincoln Counties, Wyoming, 99 ms. p., 10 pls., 1 table.

Furer, Lloyd C., 1962, Overthrusting in the Thompson Pass area, Lincoln and Sublette Counties, Wyoming, 114 ms. p., 2 figs., 9 pls., 2 tables.

Gries, John C., 1965, The structure and Cenozoic stratigraphy of of the Pass Creek Basin area, Carbon County, Wyoming, 69 ms. p., 2 figs., 6 pls., 1 table.

Hauf, Charles B., 1963, Overthrusting in the Upper Fontenelle-LaBarge Creeks area, Lincoln and Sublette Counties, Wyoming, 84 ms. p., 7 pls., 2 tables.

Landau, David, 1966, Structural geology of the northern Shirley Mountains, Carbon County, Wyoming, 83 ms. p., 10 figs., 19 pls., 7 tables.

Lawrence, J. C., 1962, Wasatch and Green River formations of the Cumberland Gap area, Lincoln and Uinta Counties, Wyoming, 124 ms. p., 6 figs., 10 pls., 1 table.

Litchford, Robert F., Jr., Structural geology and stratigraphy of a part of the Overthrust Belt near Wyoming Peak, Lincoln and Sublette Counties, Wyoming, 223 ms. p., 20 pls., 2 tables.

Nicoll, Gerald, 1963, Geology of the Hutton Lake anticline, Albany County, Wyoming, 80 ms. p., 16 pls., 3 tables.

Suydam, Robert, 1963, Overthrusting in the South LaBarge Creek area, Lincoln and Sublette Counties, Wyoming, 92 ms. p., 9 pls., 1 table.

Stratigraphy. -

Davidson, Peter S., 1966, The stratigraphy of the Lewis formation (Cretaceous) of the Laramie and Carbon Basins, Wyoming, 207 ms. p., 2 figs., 19 pls., 2 tables.

Davis, James R., 1963, The "Mesaverde" formation of the Kindt Basin, Carbon County, Wyoming, 134 ms. p., 2 figs., 7 pls., 3 tables.

_____, 1966, Stratigraphy and depositional history of the upper "Mesaverde" formation of southeastern Wyoming, 124 ms. p., 8 figs., 15 pls., 2 tables.

Ebens, Richard J., 1966, Stratigraphy and petrography of Miocene volcanic sedimentary rocks in southeastern Wyoming and northcentral Colorado, 128 ms. p., 3 figs., 28 pls., 2 tables.

Stuart, William, 1963, Stratigraphy of the Green River formation west of the Rock Springs uplift, Sweetwater County, Wyoming, 50 ms. p., 5 pls., 1 table.

A number of studies in this program were initiated during the 1966 field season. Field work has been completed for some investigations, but will continue into the 1967 field season.

Anderson, James E., Stratigraphy and depositional environments of the lower marine - continental transition of the Mesaverde formation north of Sinclair, Wyoming. All measured stratigraphic sections completed.

Dimitroff, Pencho B., Structural geology of the Foote Creek anticline, Carbon County, Wyoming. Approximately 28 square miles will be mapped during the 1966-1967 field seasons.

Duhling, W. H., Jr., Geology of the southern Bighorn Mountains, Natrona County, Wyoming. Mapping has just been started, and will continue through the 1967 field season.

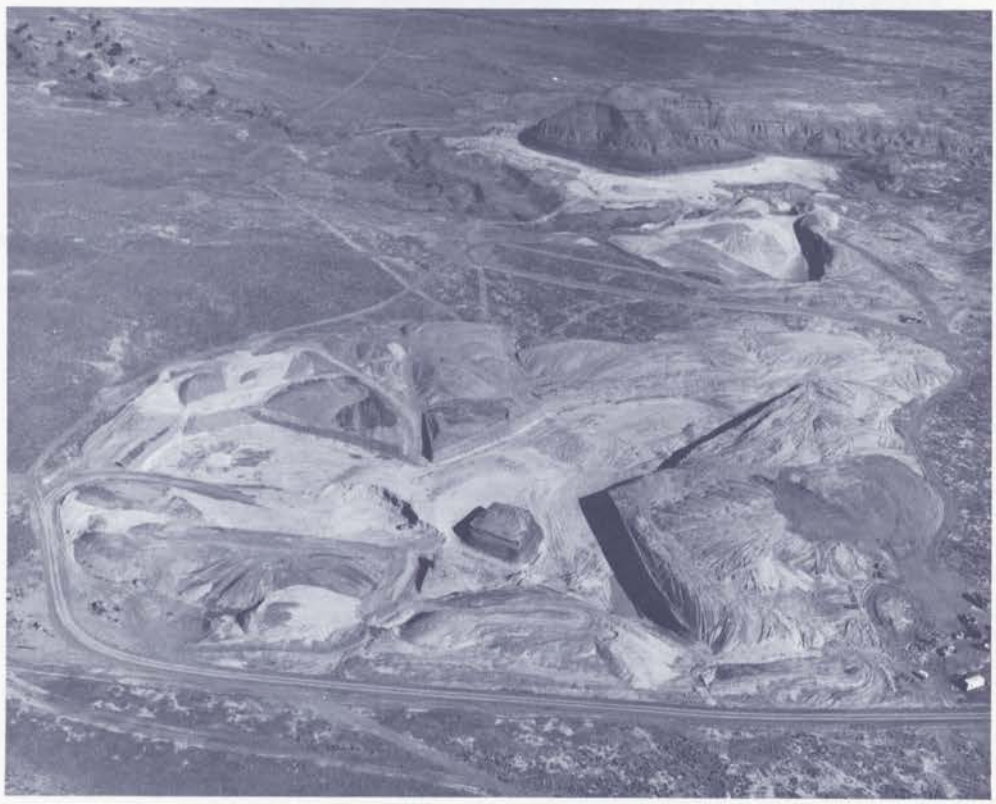
Davis, John C., Petrology of the Mowry shale (Cretaceous). Thirty-three stratigraphic sections have been measured and sampled. Laboratory work and the preparation of a report are nearing completion.

Miscellaneous Activities

Engineering geology. - During recent years 35 damsites in 14 counties were examined for the Natural Resource Board. Such studies were made to determine whether or not the foundation is adequate for the dam and whether or not there might be water leakage around or under the dam. In 1964 Dr. Wilson made a geological examination of a radioactive waste disposal site for the University of Wyoming.

Mineral inventory. - As a long range project, the Geological Survey has been compiling reliable and factual information on the known mineral deposits of the State. Our Bulletin 50, "Mineral Resources of Wyoming", which was published in 1959, has been revised and brought up to date. It is now being printed, galley proof has been read, and the bulletin will be off the press any day.

It is of interest to note how much information has been obtained since the first edition of this bulletin was issued in 1951. At that time not a single uranium deposit of possible commercial interest could be listed. Now descriptions of uranium deposits may be found for essentially every county. Wyoming ranks second in reserves, and the 1966 production was valued at $17,758,000 and was second only to New Mexico. Some deposits of commodities not listed in the original edition are coal, copper, gold, kyanite, and magnetite (iron) in Albany County; asbestos, barite, coal, copper, gold, iron, jade, kyanite, peat, and vermiculite in Carbon County; iron in Fremont County; graphite and iron in Goshen County; coal and phosphate rock in Lincoln County, beryl in Niobrara County; gold, gypsum, lead, molybdenum, and silver in Park County; talc in Platte County; and phosphate rock and taconite (iron) in Sublette County. Information on bentonite was obtained over the State, and construction materials were mapped at many places.



The Black Hills Bentonite Company's Bentonite Mine at Kaycee, Natrona County. A $400,000 bentonite mill with a 600-ton per day capacity was recently completed in Casper.

Ground water geology. - Helpful advice was given to individuals, principally ranchmen, seeking ground water supplies in the Laramie and Saratoga areas. Good geologic maps are prerequisites in ground water studies, hence those resulting from our general mapping programs are useful for that purpose anywhere in the State.

Newcastle limestone and gypsum. - The City of Newcastle, being interested in a more diversified mineral industry in the area, had set aside funds for the sampling of nearby limestone and gypsum outcrops and for analyses of the samples. Since no one with a knowledge of sampling techniques was available in Newcastle, the State Geological Survey loaned Mr. Millgate to the City for a week during June, 1966, during which time he selected strategic outcrops and sampled them. At the same time he instructed an employee of Newcastle in sampling techniques so the program could be continued.

Mineral identification service. - The Geological Survey maintains a free mineral identification service designed to be of value to prospectors, amateur rock collectors, and the general public. If the submitted specimens appear to have possible economic importance they are turned over to the Natural Resources Research Institute for assay or analysis. Several potentially important mineral deposits in the State have been brought to light through this service in the past.

Since the University of Wyoming Natural Resources Research Institute does not have a mineralogist on its staff, all mineral specimens received by that agency are turned over to the Geological Survey. Many Wyoming specimens are sent to the U.S. Bureau of Mines. These are forwarded under a formal agreement to the Geological Survey of Wyoming for identification.

COOPERATION WITH THE U.S. GEOLOGICAL SURVEY

Informal cooperation is carried on with all branches of the U.S. Geological Survey. The State Geologist has brought to the attention of the U.S. Geological Survey certain geological problems needing attention, and the Federal Survey has taken action on them. Conversely, the Federal Survey keeps us informed on the independent projects it is carrying on in Wyoming. This complete cooperation lends effectiveness and efficiency to the geological work carried on by both agencies in the State and prevents overlap or duplication of effort.

In July, 1966, the Geologic Division of the U.S. Geological Survey was independently carrying on 52 specific geological projects in Wyoming, according to Chief Geologist Harold M. James. These include regional geology (25 projects), mineralogy (1 project), stratigraphy and paleontology (13 projects), geochemistry (4 projects), geophysical studies (8 projects), and oil shale (1 project).

As of July, 1966, these projects had resulted in 32 published papers, and at that time 77 papers were being written, being processed, or were in press.

At the same time the Conservation Division of the U.S.G.S. was engaged in 10 projects involving the geological mapping of 52 quadrangles. This is part of a program leading toward the classification of 2,000,000 acres of withdrawn federal coal land, 1,000,000 acres of withdrawn phosphate land, 2,000,000 acres of withdrawn oil shale land, and 600,000 acres of withdrawn oil land.

Fund-matching projects. - Formal cooperation involving the matching of funds with the U.S. Geological Survey for specific projects in Wyoming has been carried on since 1941. In the past, projects have been undertaken on phosphate rock, titaniferous magnetite, anorthosite, cordierite, and regional geology.

The present fund-matching project is concerned with the geology of the Wind River Basin. A number of reports have been published, as follows:

Case, J.W., and Keefer, W.R., 1966, Regional gravity survey, Wind River Basin, Wyoming: U.S.Geol. Surv. Prof. Paper 550-C, p. C120-C128.

Keefer, W.R., 1963, Karst topography in the Gros Ventre Mountains, northwestern Wyoming: U.S. Geol. Survey Pro. Paper 475-B, p. B129-B130.

_____, 1964, Geologic history of the Wind River Basin, central Wyoming (Abs.): Am. Assoc. Petroleum Geologists Bull., v. 48, p. 1875.

_____, 1964, Preliminary report on the structure of the southeast flank of the Gros Ventre Mountains, Wyoming: U.S. Geol. Survey Pro. Paper 501-D, p. D22-D27.

_____, 1965, Stratigraphy and geologic history of the uppermost Cretaceous, Paleocene, and lower Eocene rocks in the Wind River Basin, central Wyoming: U.S. Geol. Survey Prof. Paper 495-A., p. A1-A77.

_____, 1965, Geologic history of the Wind River Basin, central Wyoming: Am. Assoc. Petrol. Geologists Bull., v. 49, no. 11, p. 1878-1892.

Keefer, W.R., and Love, J.D., 1963, Laramide vertical movements in central Wyoming: Contribs. to Geol., Univ. Wyo., Vol. 2, No. 1, p. 47-54.

Keefer, W.R., and Van Lieu, J.A., 1966, Paleozoic formations in the Wind River Basin, Wyoming: U.S. Geol. Survey Prof. Paper 495-B, p. B1-B60.

Love, J.D., 1964, Uraniferous phosphatic lake beds of Eocene age in intermontane basins of Wyoming and Utah: U.S. Geol. Survey Prof. Paper 474-E, p. E1-E66.

_____, 1965, Sinclair to Muddy Gap and Muddy Gap to Lander, in Late Tertiary history of the mountains, Northern and Middle Rocky Mountains Guidebook for Field Conf. E: Int. Assoc. for Quat. Research VII Congress, p. 25-27.

Love, J.D., and Keefer, W.R., 1963, Contrasting tectonics of basin margins in central and northwestern Wyoming (Abst.): Program, Rocky Mt. Sec. American Assoc. Petrol. Geols.

_____, 1965, Contrasting tectonics of crustal blocks in central and northwestern Wyoming (Abs.): Am. Assoc. Petrol. Geologists Bull., v. 49, p. 114.

A number of other reports are nearing completion, as follows:

Keefer, W.R., Structural geology of the Wind River Basin. (Completed and being reviewed)

Love, J.D., Geology of the Granite Mountains, central Wyoming: U.S. Geol. Survey Prof. Paper 495-C. (Manuscript being edited)

Love, J.D., Van Lieu, J.A., and Keefer, W.R., Stratigraphy of pre-Meeteetse Mesozoic rocks in the Wind River Basin, Wyoming: U.S. Geol. Survey Prof. Paper 495-D. (In preparation)

Cooperation with Northern Rocky Mountains Branch. - In 1942 a branch office of the U.S. Geological Survey was established in Laramie and located in the Geology Building at the University. No fund matching is involved in this cooperative program. Dr. J.D. Love is research geologist and supervising geologist, and Mrs. Laura McGrew and Mr. J.A. Van Lieu are geologists. A secretary completes the staff. Since the establishment of the office, 41 maps, charts and bulletins pertaining to Wyoming geology have been issued as Federal documents prepared in cooperation with the Geological Survey of Wyoming and the Department of Geology of the University of Wyoming. Seven publications by the Geological Survey of Wyoming have resulted.

Recently issued reports are as follows:

Keefer, W.R., and Troyer, M.L., 1964, Geology of the Shotgun Butte area, Fremont County, Wyoming: U.S. Geol. Survey Bull. 1157, 123 p., 4 tables, 16 figs., 3 pls.

Love, J.D., 1964, Uraniferous phosphatic lake beds of Eocene age in intermontane basins of Wyoming and Utah: U.S. Geol. Survey Prof. Paper 474-E, 66 p., 17 tables, 22 figs., 5 pls.

McGrew, Laura, 1963, Geology of the Fort Laramie Area, Platte and Goshen Counties, Wyoming: U.S. Geol. Survey Bull. 1141-F, 39 p., 4 tables, 5 figs., 3 pls.

Privasky, Norman, 1963, Geology of the Big Piney area, Sublette County, Wyoming: U.S. Geol. Survey Oil Map 205.

Ten geological quadrangle maps have been completed by Laura McGrew. These are identified as GQ 619 - GQ 628 and are scheduled for printing and issuance beginning in February, 1967. The following quadrangles, 9 in Platte County, 1 in Goshen County, are included:

GQ 619 - Antelope Gap	GQ 624 - Natwick
GQ 620 - Bordeaux	GQ 625 - Richeau Hills
GQ 621 - Casebier Hill	GQ 626 - Squaw Rock
GQ 622 - Ferguson Corner	GQ 627 - Wheatland
GQ 623 - Natwick SW	GQ 628 - Wheatland NE

The Four Corners quadrangle, Crook and Weston Counties, is being mapped by J.A. Van Lieu.

COOPERATION WITH OTHER FEDERAL AGENCIES

U.S. Bureau of Mines. - In 1953, the State Geological Survey entered into a formal agreement with the U.S. Bureau of Mines for the annual collection of basic data on Wyoming mineral production. A new agreement for the continuation of this work was consumated in March, 1962, and again in January, 1967. Each year a pamphlet is issued by the Bureau of Mines, containing data on mineral production and valuation, as well as discussions of new developments in the State. It is indicated that the work was prepared in cooperation with the Geological Survey of Wyoming. Briefer preliminary reports are also issued.

Rock collectors and prospectors are often not acquainted with the correct names of State and Federal agencies. Many rock and mineral specimens collected in Wyoming eventually reach the Bureau of Mines in Denver. A formal agreement has now been reached whereby the Bureau of Mines will forward such specimens to Laramie for identification by the Geological Survey of Wyoming.

Close, but informal, cooperation is carried on in other ways. Deposits of certain minerals which need core drilling, or other subsurface development, have been brought to

the attention of the Bureau of Mines and, if warranted, that agency has carried on subsurface exploratory work. There has been a free interchange of information between the Bureau of Mines and the State Geological Survey.

The Petroleum Research Center, located on the campus, has been especially helpful to the State Geological Survey in many ways. Many oil shale samples have been assayed for us by the Center without cost.

U. S. Coast and Geodetic Survey. - Since 1941 the State Geologist has served as Collaborator in Seismology and has collected reports on earthquakes felt in Wyoming. A fine seismograph has now been installed in the Geology Building by the Geology Department, and reports on the earthquakes registered are forwarded daily to the Coast and Geodetic Survey. Average frequency of quakes recorded is two per day. Few of these have their epicenters in Wyoming; other parts of the world are much more active seismically. A knowledge of earthquake frequencies in Wyoming is of value in the establishment of equitable insurance rates involving earthquake coverage, and in the design of large structures, particularly dams. The station here has also participated in the study and detection of waves created by atomic blasts.

Other agencies. - The State Geological Survey is called upon occasionally to supply geological information to many other Federal agencies, such as the Soil Conservation Service, the Grazing Service, the Reclamation Bureau, the Department of Commerce, the U. S. Army Corps of Engineers, and others. Data have been supplied to Congressional Committees and to other Federal groups or committees.

COOPERATION WITH UNIVERSITY AGENCIES

Department of Geology. - The intimate interrelationship of the Geological Survey and the Department of Geology has been pointed out earlier in this report. It should be pointed out further, however, that the field research undertaken by graduate students is of great value to the Geological Survey. These results are made available to us early. Many of the resulting theses have been published by the Geological Survey. In turn, the Geological Survey has assisted students in defraying field expenses on projects in which the Survey is interested, or by supplying thin sections or polished surfaces.

The graduate students constitute a valuable store of part-time assistance for the Survey. They have been employed to catalog oil well samples, plot oil well logs, draft geological maps and illustrations, and to undertake other assignments. The students, in turn, receive useful experience in applied geology. If it were not for the high-quality part-time help available through the employment of graduate students, the full-time staff would have to be considerably larger.

Although the State Geological Survey underwrote the thesis work of a good many graduate students during the biennium, dozens of other graduate students undertook research on the geology of Wyoming at their own expense or on funds donated by government agencies or by companies interested in mineral raw materials, the investigations serving as part of the requirements for advanced degrees. The results of all these investigations are immediately available to the Survey, even before the completion of formal reports.

Natural Resources Research Institute. - The Natural Resources Research Institute was established to carry on scientific research on the utilization of the natural resources of the State. The Geological Survey and the Natural Resources Research Institute work in close cooperation on mineral resources. The Geological Survey may bring to the attention of the Institute any mineral deposits whose quality or uses might be determined through laboratory investigations. In turn, the Institute supplies the State Geological Survey with needed analytical information on mineral specimens submitted as an aid in determining the potentialities of certain deposits.

COOPERATION WITH STATE DEPARTMENTS

Natural Resource Board. - The State Geological Survey stands ready to cooperate with the Natural Resource Board in any possible manner on the mineral resources of the State or in engineering or ground water problems on which geology has a bearing. The Geological Survey has supplied data on mineral deposits, made examinations of potential dam sites, conferred on ground water problems, and participated in public conferences held over the State on natural resources. In turn, the Natural Resource Board paid most of the cost of compiling and printing Geological Survey of Wyoming Bulletin 50, "Mineral Resources of Wyoming" and its revised second edition. In addition they have given financial aid to help complete the study of the Tertiary rocks of southeastern Wyoming.

Commissioner of Public Lands. - Prior to the issuance of permits for the collection of fossils in Wyoming, which are obtained from the State Commissioner of Public Lands, the endorsement of the State Geologist is necessary. The Geological Survey also has been called upon to offer opinions on mineral associations in respect to State mineral leases, or on the mineral or nonmineral character of certain lands. These are strictly geological matters, and each one appears to constitute an individual problem.

State Highway Department. - From time to time the Geological Survey is asked to collaborate on problems in engineering geology which confront the Highway Department.

State Game and Fish Commission. - Through the years the Geological Survey has assisted the Game and Fish Commission, principally on problems of water supply for hatchery use or in dam site investigations.

Oil and Gas Conservation Commission. - The State Geologist, by law, is a member of the Oil and Gas Conservation Commission.

OIL WELL SAMPLE REPOSITORY

The Geological Survey's oil well sample repository contains a very important collection of cuttings and cores from deep wells drilled over the State. The collection has been accumulated through the cooperation of oil companies operating in Wyoming who have donated samples and cores in the belief that they will be properly catalogued, stored, and preserved for the future at the University.

The repository contains catalogued sets of samples from over 937 wells drilled in Wyoming representing 6,103,680 feet, or 1,156 miles, of drilled hole. The collection also contains samples from 310 wells drilled in neighboring states, representing 332 miles of drilled hole. The cost of drilling the wells from which the samples came was probably somewhere between $75 and $100 million. Samples are commonly the only tangible result of large sums of money spent in drilling deep dry holes.

The samples are useful in the further search for oil, particularly now that subsurface data are being used in Wyoming as the main tool in exploring for stratigraphic type fields. Many petroleum geologists visit the repository to examine sets of samples, or the Geological Survey will send sets elsewhere for examination. The samples also give valuable information on the depth, thickness, and character of water-bearing sands.

The University Board of Trustees has recognized the importance of the repository by allowing 2,000 square feet of space in the basement of the Geology Building in which storage bins were built by the University. Subsequently the Board of Trustees assigned a Butler Hut near the Geology Building to the Geological Survey, and again paid for the erection of storage bins.

The unfortunate point is that we have simply run out of storage space. We were recently offered all the cores from exploratory holes drilled at all the missile sites at the Cheyenne Minute Man Missile Base. These cores would have been invaluable in the ground water geology

of southeastern Wyoming and the general geology of the area. We simply had to refuse them because of lack of storage space. After our refusal the University of Nebraska and Colorado State University were offered the cores and they are now stored at those institutions.

Partial view of oil well storage bins. There are five rows of bins, each row 70 feet long. Additional samples are stored in a steel building adjacent to the Geology Building.

The solution to this problem is not clear. There is an old building behind Geology Building which is vacant and slated for demolition. If this could be used it might serve until a legislative appropriation would enable the construction of a warehouse somewhere on University property.

The situation will get worse. We have had to refuse other desirable collections of cores or samples, but a major problem lies in the fact that the American Stratigraphic Company is going out of the sample storage business. The Wyoming Geological Association has formed a committee to try to prevent Amstrat's large collection from leaving the State and for storage by the State on a permanent basis. The logical move would be to combine that collection with the one here at the University, should space become available.

Among the cores are some of untold scientific value, and which are irreplaceable since no core holes will ever be drilled near to these in the future. To list all the important cores would involve lengthy discussion, but a few of the outstanding ones are worthy of mention.

We have all the cores from holes drilled in trona exploration in the Green River Basin by the Olin Mathieson Chemical Company, Diamond Alkali Company, and others. Through a special grant made by the Board of Trustees to the Geology Department, it was possible to transport the 20,278 feet of cores to Laramie for storage in the Survey's repository. The cost of drilling the core holes exceeded $1,000,000.

A few years go the Mountain Fuel Supply Company drilled a well which was cored continuously with diamond bits from a depth of 6,404 feet to the total depth of 9,290 feet. The Company paid all costs for transporting this great heavy mass of rock from Rock Springs to Laramie. The cores exhibit the rock section from near the top of the Weber sandstone almost to the base of the Cambrian rocks. The value of the cores can be appreciated when it is realized that the nearest surface exposures of these rocks are in the Uinta Mountains, about 50 miles south of the well; in the Wind River Range, about 65 miles north of the well; in La-Barge Ridge, about 75 miles northwest of the well; and in the Rawlins uplift, about 95 miles east of the well. The cores constitute the only record of the formations which underlie an area of about 6,000 square miles.

Shell Oil Company placed with us, the cores from a deep well in the Sheridan area. The $3\frac{1}{2}$-inch cores were cut with diamond bits and every inch of the mile of sedimentary rocks making up the precipitous front of the Bighorn Mountains west of Sheridan may be seen in the cores in the basement of the Geology Building in Laramie.

A 10,000-foot well was completed in January, 1965, which was drilled in the crystalline Precambrian rocks of the Wind River Mountains near Pinedale by the United States Air Force. No well in Wyoming has ever penetrated Precambrian rocks to such a depth. The cuttings and cores from this well have been donated to the State Geological Survey and research on them is now taking place at the University of Wyoming and at other universities and federal research laboratories over the country.

PUBLIC EDUCATION

Wyoming industrial rock and mineral sets. - Sets of 16 important Wyoming rocks and minerals have been prepared in special compartmented boxes. Composition, properties, uses, and occurrences are given inside the lid. These sets are available to Wyoming secondary schools for instructional purposes. A simplified brochure on Wyoming mineral resources has been prepared for use in conjunction with the sets of specimens. In order to fill the many requests received from out-of-state teachers, school children, and other interested persons for specimens of Wyoming rocks or minerals, special sets of two specimens have been prepared, and hundreds of these have been distributed during the biennium.

Tourist information. - The hobby of "rock hounding" has become a very popular one in recent years and there are literally millions of persons who are amateur mineralogists or paleontologists and lapidarists. Many of these persons come to Wyoming as tourists and prior to their visits ask for information on the occurrences of rocks, minerals, and fossils in the State. A mimeographed pamphlet had been used to fill such requests, but the need for a better, more comprehensive one was apparent.

In the writer's estimation, one of the most important contributions we have ever made was the issuance in late 1965 of our Bulletin 51, "A Field Guide to the Rocks and Minerals of Wyoming", by Dr. William H. Wilson. This 72-page booklet describes the physical and chemical nature of various minerals, their classification and recognition. A summary of the geological history of Wyoming is given. The main text comprises descriptions of 67 different common Wyoming minerals. The nature and classification of igneous, metamorphic and sedimentary rocks is then given, followed by descriptions of 34 common Wyoming rocks. A very useful glossary and a bibliography completes the bulletin. There are 24 illustrations, mainly of rocks and minerals. As a sidelight, after some 75 years of publication this is the first Geological Survey bulletin to have a colored photograph for a cover - Devils Tower.

There is a need, also, for a companion guide to Wyoming fossils, but this can be done only when a qualified person can be found to prepare such a publication. As future projects, we have planned on the compilation of popular guides to the geology of State parks, mountain ranges, and other areas of geological interest.

PUBLIC SERVICES

Office callers. - Almost every day representatives of oil and mining companies or other individuals interested in mineral resources call at the Geological Survey offices. One of the most effective points in handling these callers is that here in one building such persons may take advantage of advice and information available from the staffs of the State Geological Survey, the U.S. Geological Survey and the Department of Geology of the University. In addition, it is possible for such persons to confer also with other agencies located on the campus, such as the Bureau of Mines Petroleum Research Center, the Natural Resources Research Institute, the Engineering College, or other departments.

Correspondence. - A large volume of inquiries seeking information on Wyoming mineral resources, petroleum geology, and geology in general is received daily by the office. Properly answering this mail constitutes an imposing chore which becomes more burdensome each year.

Topographic sheets. - The Geological Survey carries a supply of the topographic maps covering Wyoming. These are useful to hunters, fishermen, campers, prospectors, ranchmen, tourists, and others, and many hundreds of copies are distributed each year.

Air Photos. - The entire State has aerial photographic coverage, but because of the cost of such photos it has been impossible to purchase more than a fraction of all the available ones. It is hoped that by adding to the air-photo library from time to time, it will eventually be possible to obtain complete coverage. These photographs are very useful to anyone seeking information on surface features, or the geology, of specific areas.

PUBLICATIONS, MAPS AND REPORTS

Geological examinations have little value unless the accumulated information is made available to the public. Every effort has been made, within limited resources, to publish printed reports on the results of projects of major magnitude. About 300 copies of each publication are deposited in libraries in the United States and foreign countries. Other copies are distributed to individuals, corporations, agencies, and others on request.

Unpublished reports are placed on open file for public examination and photocopies are available to interested parties. Copies of more comprehensive unpublished reports are placed in the Geology Library where they may be consulted or borrowed.

Copies of unpublished regional geological maps made by more than 200 graduate students at the University as part of the requirements for advanced degrees are available to the public through the Geological Survey. Over the years thousands of these maps have been distributed, principally to oil companies.

Along with increased activity in petroleum and uranium exploration in Wyoming, there has been increased demand for our publications. Many of the earlier ones are now out of print and no longer available for distribution.

EPILOGUE

The State Geologist will complete his 26th year of office on March 1, 1967. During the 26 years the writer will have served under 10 Governors - Smith, Hunt, Crane, Barrett, Rogers, Simpson, Hickey, Gage, Hansen, and Hathaway. The third member of the Advisory Board of the Geological Survey is the President of the University. President Lewis Morrill, President George Duke Humphrey, and President John Fey were all very helpful in Survey affairs. I am particularly grateful for Dr. Humphrey's 18 years of interest and wise counsel. President John King has just assumed office, but will, no doubt, be as helpful as his predecessors.

Although there have been times when it seemed that little progress was being made, it is apparent today that our comprehension of Wyoming geology is immeasurably better than

it was in 1941. This increased knowledge is the result of the combined efforts of the many geologists who have worked in the State -- State and Federal geologists, staff members and students from this and many other universities, and petroleum and mining geologists. There remains much to be learned, however, and we are constantly being surprised by the discovery of some new unexpected geological phenomenon. This makes our work still more fascinating.

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