

Please offer any suggestions for handling comments in final draft copy
Mike Wright
Dick Meyer

DEPARTMENT OF NATURAL RESOURCE DEVELOPMENT
SOUTH DAKOTA GEOLOGICAL SURVEY

SCIENCE CENTER, UNIVERSITY
VERMILLION, SOUTH DAKOTA 57069

16051 624-4471

GEORGE 7/31
PLEASE PREPARE RESPONSE
INFO
THANKS GM

July 26, 1979

Mr. Ben Lunis
EG&G Idaho
P. O. Box 1625
Idaho Falls, ID 83401

Dear Mr. Lunis:

The June 1979 draft for South Dakota Hydrothermal Commercialization Baseline reached this desk for scrutiny. This draft was prepared for the Department of Energy-Idaho Operations Office and Resource Applications, Geothermal Resource Office by EG&G, Idaho, Inc., Idaho Falls, Idaho, and edited by J. A. Hannay and B. C. Lunis. On page iv it is stated, "A number of people from EG&G and the Earth Science Laboratory of the University Research Institute have contributed to this draft document." For some reason author or authors want to be anonymous.

On page 6-4 under section B. "This program, commonly referred to as the PRDA program, is to provide funding for engineering and economic studies for direct applications of geothermal energy. . . The cost of studies is up to \$125,000 each, and covers a study period of six to twelve months." The following paragraph continues, "Under the PRDA program, a general study of the Madison formation underlying western South Dakota has been completed [1]." On page 6-9 we find that the reference [1] refers to "Geothermal Potentials In South Dakota" which was authored by Schoon and McGregor and was published as Report of Investigations 110 by the South Dakota Geological Survey in 1974. The South Dakota Geological Survey has never received monies from DOE/DGE or any other federal agency in cooperation with the publishing of the referenced report.

mistake
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Two possibilities exist for the above discrepancy. Either the draft contains a serious error or a misunderstanding of fund commitments. Duncan McGregor and Robert Schoon were visited by Dr. Gerald Brophy of the U.S. DOE/DGE and Duncan Foley of the University of

Mr. Ben Lunis
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Utah Research Institute. During this visit, September, 1978, Dr. Brophy showed us a line item in the DOE budget that indicated the sum of \$150,000 was budgeted for the South Dakota Geological Survey. It was said that future correspondence would reveal the nature of the program that was targeted to receive the funds. No correspondence has been received nor did the South Dakota Geological Survey receive any federal monies for a geothermal project.

*URI's
reaction?*

Your draft should make more reference to the Inyan Kara Sandstone, the Red River Dolomite and possibly the rocks of Permian-Pennsylvanian age. Although these units may not have the potential that the Madison has, they should not be ignored.

yes

On page 2-3 the sub-heading "Major Active Developments" is confusing. Is it meant to designate a project that is currently being developed? Or is it meant to designate a project that has been completed and is currently active? If so, the Midland operation should certainly be mentioned even though it was installed before the DOE/DGE was born.

*private
lease info
normally
not
available*

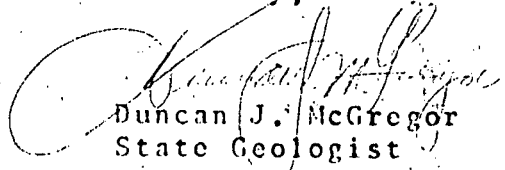
Also on page 2-3 under the sub-heading "Geothermal Leases" you mention federal, state and private leases. Do you mean that private leases are not available? Or do you mean that you have not spent time and effort to collect the information?

*URI's
reaction*

Page 3 contains two sections. In the second section you list "Prospects: None." It appears that DOE/DGE has made little effort or spent any money to back your conclusion. As yet no one at the federal level seems interested in determining the source of heat to insure a constant supply of thermal waters.

Your report covers "old ground" and offers nothing constructive. Certainly data for the baseline has yet to be gathered.

Sincerely,


Duncan J. McGregor
State Geologist

DJM:co
cc: Harry Christianson
Warren R. Neufeld



THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY

Johns Hopkins Road, Laurel, Maryland 20810
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MAR 21 1977

CQO-1919

14 March 1977

South Dakota State Geological Survey
Science Center
University of South Dakota
Vermillion, S.D. 57069

Attention: Dr. D. J. McGregor

Subject: Revision of Letter of Agreement

Enclosure: Draft Copy of Letter of Agreement

Dear Dr. McGregor:

Please find a draft copy of the revised Letter of Agreement to add geothermal interests to the existing USGS Madison Study. Please advise me if you have any questions.

In respect to Dr. Decker, I have suggested that he also be retained by the USGS to look at heat flow on the western side of the Black Hills. This would ensure an integrated program for the two areas. To my knowledge, this probably will come to pass with the addition of Dr. A. H. Lachenbruck of USGS/Menlo Park, also working in the area. As I suggested over the telephone, I would suggest that you contact Dr. Decker and obtain his estimate for the effort you will support and add to it the cost of extending any planned or potential oil or gas test wells to obtain cores of basement rock, such as the one at the town of Quinn, this coming summer. Dr. C. Nichols, who will fund this effort, is desirous of getting started as soon as possible and this effort does not have to wait on the finalization of the Letter of Agreement.

Finally, can you suggest a method of integrating the output of the ERDA-sponsored effort on the Madison at the South Dakota School of Mines together with the eventual output of your office under this extended program?

Sincerely yours,

for
F. C. Paddison
Assistant Director
Advanced Research Programs

FCP:mms

DRAFT

MAR 21 1977

LETTER OF AGREEMENT

The Application of the Study of the Hydrology of the
Madison Limestone for Geothermal Resource Definition

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The USGS/WRD Madison Program Application to the

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LETTER OF AGREEMENT

The Application of the Study of the Hydrology of the
Madison Limestone for Geothermal Resource DefinitionIntroduction

The Water Resources Branch of the Department of the Interior Geologic Survey is currently well advanced in a substantial technical program to study the hydrology of the Madison limestone and associated water-bearing formations in parts of Montana, Nebraska, North Dakota, South Dakota and Wyoming. This letter outlines a broadening of that study to provide a detailed characterization of the thermal properties of the waters and possible withdrawal rates in parts of South Dakota, and possibly in the future, Wyoming and Nebraska.

The Madison water in parts of Wyoming and South Dakota is heated by an unknown mechanism to temperatures much higher than it would normally be at its depth. The Madison is an artesian aquifer system and is used in many communities solely, or together with surface run-off water, as the domestic water supply. These communities and others who currently do not tap the Madison are interested in analyzing the engineering, and costs of using these waters for community geothermal heating and cooling. Further, these communities wish technical assurance that the resource has a reasonable life expectancy and that potential use will not lower pressure or temperature to the

point where a community system would no longer be cost-effective. The individual State Geologic Survey offices, together with the Division of Geothermal Energy of the Energy Research and Development Administration (DGE/ERDA), join with these communities in the requirement to develop the necessary data. It appears that the current Madison study, with modest modifications, could provide these data.

The Geothermal Branch of the U.S. Geological Survey (USGS) is in the process of revising Circular 726, "An Assessment of Geothermal Resources of the United States--1975" to include lower temperature resources and are therefore also an interested participant in this revised program.

Purpose

This agreement is not a legal or binding document and is intended for the following purposes:

1. Because of current national focus on geothermal energy, the many interests in the thermal properties of the Madison waters, particularly the characteristics and location of its heat source.
2. To outline the desired additional scope in the Madison program.
3. To provide a mechanism for the involvement of geothermal interests in the Madison program.
4. To provide a mechanism to facilitate the contracting and funding by ERDA of the effort required to augment the additional scope of work implied in this agreement.

5. To establish in each state concerned, as appropriate, a point of contact responsible for promulgated engineering data. Initially, only the state of South Dakota is cited.

Objectives of an Expanded Madison Program

The primary objective of this program is to assess and characterize the Madison waters and related thermal aquifers as geothermal resources. A second objective is to extend the hydrologic simulation of the aquifer systems to provide predictions of the effects of usage of the waters in South Dakota. A third objective is to extend existing programs to include geochemical analyses of the thermal waters, as well as conventional stratigraphic core heat-production studies, to assist in the definition of the type and location of the source of heat.

The Current Madison Program

The Central Regional Office of the Water Resources Division of the Department of Interior Geologic Survey, in cooperation with states of Montana, North Dakota, South Dakota and Wyoming, are well into the initial phase of a multiyear program whose objectives are:

1. Determine the quantity of water that may be available from the Madison aquifer.
2. Define the chemical and physical properties of the water.
3. Determine the effects of existing developments on the potentiometric head, storage, recharge and discharge, springs, streamflow, and the pattern of ground-water flow.

4. Predict the probable hydrologic effects of proposed withdrawals of water for large-scale developments at selected rates and locations.

5. Determine the locations of wells and the type of construction and development of deep wells that would obtain optimum yields.

6. Design a network of observation wells and stream gates to monitor the effects of additional development on the hydrologic system.

Geothermal Potential of the Madison Waters

The Madison, the Dakota and the Fall River formations are substantial aquifers which underlie all or parts of the states of Montana, Wyoming, North Dakota, South Dakota, and Nebraska. In some, if not all, of these states the waters reach temperatures of interest to geothermal space heating, refrigeration and moderate temperature agricultural use. The temperatures in Wyoming, Montana and North Dakota appear to be consistent with the normal gradient for the formation depth; however, in South Dakota the water temperatures are hotter than would be expected from the normal thermal gradient.

In addition, the depth to the Madison is such that it is economically practical to recover the thermal energy. A further consideration is that, in the western half of the state of South Dakota, the region under which the Madison is located, is devoid of fossil fuels and energy transportation systems are limited to truck-transported fuel oil and liquid gas. Accordingly, the

initial emphasis for the assessment of the Madison waters developed for geothermal use will concentrate on the state of South Dakota.

The USGS/WRD Madison Program Application to the Geothermal Analysis of Western South Dakota

The practical economics of developing community heating/cooling systems requires definitive engineering data on the Madison and related aquifers throughout the region of western South Dakota where it is to be found. Further, reasonable estimates in regard to the tectonic stability of the region and the perpetuation of the thermal properties of the water are desired. The effects of substantial withdrawal on the quality of the water and on the artesian properties of the aquifer and its thermal properties are most important. Prospectively the potential uses in the state of Wyoming for the coal slurry pipeline and geothermal community space heating and cooling by towns with a population over 300 in South Dakota should be considered. Finally, environmental problems of withdrawal and reinjection, in areas where required, must be included.

The current Madison study is developing much of the data implied by the preceding discussion; however its primary emphasis is on the western side of the Black Hills, where the two current test wells have been or are in the process of being drilled.

The Madison, Fall River and Dakota formations on the eastern side of the Black Hills are rather well known geologic systems; however, prior to the establishment of a national geothermal program there has not been the need for a systematic

compilation or development of engineering data on these aquifer systems sufficient for detailed engineering and cost-estimating for the development of the resource for the geothermal use of the waters. Nevertheless, a considerable body of data does exist and, accordingly, the first task to to compile systematically and analyze these data, determining what additional data, if any, are required and whether these data will naturally be obtained as part of the current USGS Madison study and, if not, how best to obtain these data.

It is agreed that the South Dakota State Geological Survey (SDSGS) will carry out this task, cooperating with USGS/WR who, in turn, will extend their modeling of the Madison to predict water temperatures, availability and usage effects in South Dakota. To this end it is clear that geochemical dating of the water and their lateral velocities in South Dakota are desired, as is geochemical determination of the thermal history of the waters. Working with regional heat-flow specialists, it will be necessary for the SDSGS to determine heat production in basement material in South Dakota and the insulating properties of the sedimentary cover, while the USGS is to be responsible for a similar effort in Wyoming. These two areas are to assist in the location of the heat source or sources and provide data for the longer term utilization of hot dry rock or other exploitation techniques. As part of this

strategy, DGE/ERDA, through its Region 5 Operations Research Contractor, will be responsible for applications scenarios.

Finally, consideration should be given to the drilling of one or more test wells to the Madison on the eastern side of the Black Hills. These wells should extend through the Madison formation into the basement Precambrian and/or Cambrian rock. Cores from those formations, together with any other similar cores, should be examined for concentrations of radiogenic elements as part of the general heat-flow study to pinpoint the location and type of heat source.

Identifiable Additional Effort and Individual Responsibilities

1. The addition of the geothermal considerations to the Madison study can well be incorporated within the basic organization and information structure that currently exists. To facilitate this, it is suggested that a representative of DGE/ERDA and USGS/Menlo Park become members of the Madison Technical Committee.

2. The SDSGS assumes the responsibility for the determination of the characteristics of the Madison, the Fall River, the Dakota, and any deeper thermal aquifers in regions of the state of South Dakota. This includes a thorough compilation, analysis and review of existing data, leading to recommendations for gathering further data, if required. In addition, a program to determine the heat-flow provinces within the state is desired as an aid in locating the heat source of Madison waters. Finally,

The SDSGS will serve as a point of contact for potential users of geothermal waters in South Dakota, where they can go to obtain data and predictions from the USGS hydrologic model or other data sources (see below).

3. The USGS Water Resources Division/Denver, together with its South Dakota office in Huron, assumes the responsibility for the extension of the hydrologic simulation of the Madison and associated aquifers to provide temperatures, draw-down and predictions of possible water production in South Dakota where these aquifers are located.

4. The USGS/WR Reston together with USGS/Menlo Park will assume the responsibility of analyzing the results of geochemistry to determine the thermal history of the Madison waters, particularly in South Dakota. USGS/Menlo Park in cooperation with state heat flow scientist will also conduct heat-flow measurements and calculations in the state of Wyoming, in parallel with those done in South Dakota, to assist in location and identification of the thermal source of the waters.

5. The Geothermal Branch of USGS/Menlo Park is responsible for integrating the data for the state of South Dakota, together with that from Wyoming, North Dakota and Montana, as appropriate, for a revision to Circular 726 scheduled to include U.S. geothermal resources below 90°C.

6. The task of DGE/ERDA is to provide the link between the resource definition and the user community. In this effort ERDA will be supported by Region 5 Operations Research Contractor, the Applied Physics Laboratory of The Johns Hopkins University.

In connection with the additional effort to add geothermal interests to the Madison study, DGE/ERDA will advise with and support with funding, as appropriate and mutually agree upon, the tasks of the other participants. In connection with the latter, DGE/ERDA will support, as appropriate, the engineering for specific users.

Milestones

This Letter of Agreement comes into effect upon formal signing of this agreement.

SDGS

USGS/WR

USGS/Menlo Park

USGS/Reston

ERDA/DGE

purpose. Details are still being worked out to make it as easy as possible to move into the GLGP once your reservoir has been confirmed.

(2) The State Resource Assessment Program and the State Commercialization Planning Program - Various states have teams working to assess geothermal resources (the former program) and to facilitate all aspects of industrialization of geothermal energy (the latter program). We encourage you to contact these state teams for

assistance, as they can assist you in unique aspects of geothermal energy. Note, however, that due to potential conflicts of interest, these teams cannot prepare proposals nor portions of proposals, nor can they interpret the DOE solicitation document, nor review or pass judgment on your proposal.

(3) Technical Assistance Program - This program offers information to developers to help them conceive geothermal direct applications appropriate to their potential resource.

More information on these programs can be obtained from the DOE-Idaho Operations Office in Idaho Falls, Idaho, or, for a given program, by contacting the specific individual in your state. We list below the names of individuals, with their addresses and phone numbers, to contact for these programs by state. A copy of the *DOE Solicitation for Cooperative Agreement Proposals* can be obtained from Ms. Nina Ussey, SEP Secretary, Department of Energy, Room 358, Idaho Operations Office, 550 Second Street, Idaho Falls, Idaho 83401.

State Resource Assessment Teams

ALABAMA	Gary V. Wilson Geological Survey of Alabama P.O. Drawer 0 University, Ala. 35486	205-349-2852	HAWAII	Charles E. Helsely Hawaii Institute of Geophysics University of Hawaii 2525 Correa Rd. Honolulu, HI. 96822	808-948-8760
ALASKA	Donald L. Turner Geophysical Institute University of Alaska Fairbanks, Alas. 99701	907-479-7198	IDAHO	John C. Mitchell Department of Water Resources 450 Washington Street Boise, Id. 83702	208-334-4477
	Ross G. Schaff Alaska Div. of Geological and Geophysical Surveys 3001 Porcupine Drive Anchorage, Alas. 99501	907-277-6615	KANSAS	Don W. Steeples Kansas Geological Survey University of Kansas Lawrence, Kans. 66044	913-864-3965
ARIZONA	W. Richard Hahman, Sr. Arizona Bureau of Geology and Mineral Technology Geological Survey Branch 845 N. Park Ave. Tucson, Ariz. 85719	602-884-2733	MISSISSIPPI	Alvin R. Bicker P.O. Box 5348 Jackson, Miss. 39216	601-354-6228
CALIFORNIA	Roger C. Martin California Division of Mines and Geology 107 South Broadway, Rm 1065 Los Angeles, Calif. 90012	916-323-0967	MONTANA	John Sonderegger Montana Bureau of Mines and Geology Butte, Mont. 59701	406-792-8321
COLORADO	Richard H. Pearl Colorado Geological Survey 1313 Sherman Ave., Room 715 Denver, Colo. 80203	303-839-2611	NEBRASKA	William D. Gosnold Dept. of Geography-Geology University of Nebraska Omaha, Nebr. 68132	402-554-2457

	Duane A. Eversoll Nebraska Geological Survey University of Nebraska Lincoln, Nebr. 68588	402-472-3471	OREGON	Donald A. Hull Oregon Department of Geology and Mineral Industries 1069 State Office Bldg. Portland, Oreg. 97201	503-229-5580
NEVADA	Dennis Trexler Nevada Bureau of Mines and Geology University of Nevada Reno, Nev. 89557	702-784-6691	TEXAS	Charles M. Woodruff Texas Bureau of Economic Geology University Station, Box X Austin, Tex: 78712	512-474-5994
NEW MEXICO	Chandler A. Swanberg New Mexico State University Physics Department Las Cruces, N. Mex. 88001	505-646-1920		David M. White Texas Energy and Natural Resources Advisory Council 411 W. 13th St., Room 800 Austin, Tex: 78701	512-475-5588
NEW YORK	Burton Krakow New York State Energy Research and Development Agency Bldg. N. 2 Rockefeller Plaza Albany, N.Y. 12223	518-465-6251		Rober F. Roy Dept. of Geological Science University of Texas El Paso, Tex. 79968	915-747-5501
	James R. Dunn Dunn Geoscience 5 Northway Lane N. Latham, N.Y. 12110	518-783-8102	UTAH	J. Wallace Gwynn Utah Geological and Mineral Survey 606 Black Hawk Way Salt Lake City, Utah 84108	801-581-6831
NORTH DAKOTA	Kenneth L. Harris North Dakota Geological Survey Grand Forks, N. Dak. 58202	701-777-2231	WASHINGTON	J. Eric Schuster Washington Dept. of Natural Resources Olympia, Wash. 98504	206-753-5327
OHIO	Frank L. Majchszak Ohio Geological Survey Fountain Square Columbus, Ohio 43224	614-466-5344	WYOMING	Edward R. Decker Department of Geology University of Wyoming Laramie, Wyo. 82071	307-766-3278
OKLAHOMA	William F. Harrison Oklahoma Geological Survey University of Oklahoma 830 S. Oval Norman, Okla. 73019	405-325-3032			

State Commercialization Planning Teams Principal Contacts

STATE	NAME & ADDRESS	NUMBER		
California	Hugh McGomey Neil Moyer Director of Geothermal Office California Energy Commission 1111 Howe Street Sacramento, Calif. 95825	916-920-6025		7770 948-2000
Colorado	Richard H. Pearl, Chief Ground Water Investigations 715 State Centennial Bldg. 1313 Sherman Street Denver, Colo. 80203	303-839-2611		FTS 239-3131
Hawaii	James Woodruff Dept. of Planning & Economic Development State of HI - Box 2359 Honolulu, Hawaii 90804	808-548-4195		
Alaska	Don Markle Division of Energy & Power 338 Denali Street - 7th floor, Mackay Bldg. Anchorage, Alas. 99501	907-276-0508 399-0150		
Arizona	Don White Dept. of Chemical Engineering University of Arizona Tucson, Ariz. 85721	602-626-1224/5 261-3900		

Bill Eastlake or Lee

Idaho ~~Dave McClain~~ 208-384-3800
Deputy Director - Office of Energy
State House
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MT Dept of Natural Resources & Conservation
32 South Ewing
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4624
585-5011

New Mexico George Scudella, Director 505-827-2472
Energy Resource & Development Division
Energy & Minerals Department
Santa Fe, N. Mex. 87501
Dial 8-476-2471

Nevada Kelly Jackson, Assistant Director 702-885-5157
Nevada Department of Energy
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North Dakota Bruce Gaugler 701-224-3444
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Governor's Office
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Oregon Dave Philbrick *Phil* 503-378-5584
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423-4111

South Dakota Phil Lidel 605-773-3603
South Dakota Office of Energy Policy
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Utah Stanley Green, Director 801-553-6071
Division of Water Rights
200 Empire Bldg. - 231 E.
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Washington Gordon Bloomquist *Gordon* 206-754-0774
Washington State Energy Office
400 East Union Street
Olympia, Wash. 98504
390-6111

Wyoming *Karen Marcote* ~~Mark James~~ 307-766-6760
Geothermal Commercialization Office
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University Station
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FTS 328-1110

Technical Assistance Centers

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