GL02773-3

Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, Idaho 83401

MAR 9 1978

Dr. Phillip M. Wright
University of Utah
Research Institute
391 Chipeta Way
Salt Lake City, UT 84108

Dear Mike:

In a phone conversation with Duncan on March 7, 1978, we discussed the position of the State of Montana with respect to the State-Coupled Programs.

Enclosed is a copy of a proposal received November 19, 1977, regarding examination of geothermal resources near West Yellowstone. This is the only proposal I have seen come into this office covering resource assessment; it was never funded. This essentially fills you in on Montana's status to date.

In addition to their proposal, I am sending you a copy of the summary of work being conducted in the Montana Geothermal programs by the various agencies of the state as of November 19, 1977. This summary was enclosed with a letter to David Crockett from John Sonderegger at the time of the submission of their proposal.

Mr. Griffith has okayed travel for me to visit Montana with you and Duncan for discussions about the State-Coupled Programs. He has also approved travel to Wyoming whenever that deal goes through. Let me know when these trips will be set up.

Will be in touch.

Very truly yours,

Maggie

Margaret A. Widmayer
Geothermal Energy Branch

Enclosures:
As stated

Montana Geothermal Summary

1. U.S.G.S.

   a. Basic data report in review stage for Open File distribution. Basically a large amount of geochemical data and its interpretation (temperature at depth?).

   b. Compilation and analysis of pre-existing data is nearly complete. Prospects for shallow, high temperature geothermal systems are poor. Low temperature potential is still being evaluated (test drilling ongoing).

   c. Two reports on Ennis and Helena areas due for completion is fiscal 78.

   d. Final report will be started at end of fiscal 78.

   e. Bob Leonard is currently sitting a drilling rig at Ennis. Two holes planned--1st, 350 feet deep, is completed and they are starting a second, 500 feet deep, hole.

2. M.B.M.G.

   a. Phase zero study of shallow geothermal potential in the Madison Group carbonate aquifer. Study completed--maximum potential in Little Rocky Mountains area.

   b. Centennial Valley reconnaissance study. Hydrologic inventory completed, most of water samples collected (comparitive samples next spring for seasonal fluctuation). Geologic mapping initiated.

   c. Mine-water temperature study-some winter samples still to be collected. Final report due April, 1978. Two minor anomalies located; no waters above 20°C encountered.

3. U.S.F.S. (w/B.L.M.)

   a. E.I.S. for Marysville area completed.

   b. E.I.S. for Boulder area nearly completed.

   c. E.I.S. for West Yellowstone in preparation.

Montana College of Mineral Science and Technology
Montana Bureau of Mines and Geology
Project Proposal

SUMMARY PAGE

Submitted To:

Mr. David Crockett
Geothermal Energy Branch
U.S. Department of Energy
Idaho Falls, Idaho 83401

Submitted By:

Marvin R. Miller, Chief, Hydrology Division
John L. Sonderegger, Hydrogeologist
Montana Bureau of Mines and Geology
Butte, Montana 59701

Project Title:

Supplementary geothermal studies in Montana.

Project Director:

John L. Sonderegger

Investigators:

John L. Sonderegger
Robert N. Bergantino
Wesley M. Bermel

Project Duration:

May 1, 1978, to September 30, 1980

Financial Agency for Grant:

Grant and Contracts Office
Montana College of Mineral Science and Technology
Butte, Montana 59701

Total Grant Requested:

$263,599

Project Proposal

Title: Supplementary geothermal studies in Montana.

Preliminary Statement:

This application for research funding is designed to provide needed information for federal, state, and local government agencies; emphasis has been placed upon "areas of omission" where either basic investigations or data aquisition, processing, and presentation have been omitted by federal and state geothermal resource evaluation programs. Tasks to be accomplished include: (1) the evaluation of geothermal potential in the vicinity of West Yellowstone, Montana; (2) study of hot springs with calculated subsurface temperatures $\geq$ 140°C, with reports and recommendations on the location of test drilling sites; (3) processing and entering of approximately 2,500 chemical analyses from wells and springs to the U.S. Geological Survey W.R.D. computer files (these data will then be accessible for inclusion in the Geotherm data file); and (4) field investigations to upgrade the quality of data available on hot and warm springs in Montana, and to evaluate geothermal gradients where possible.

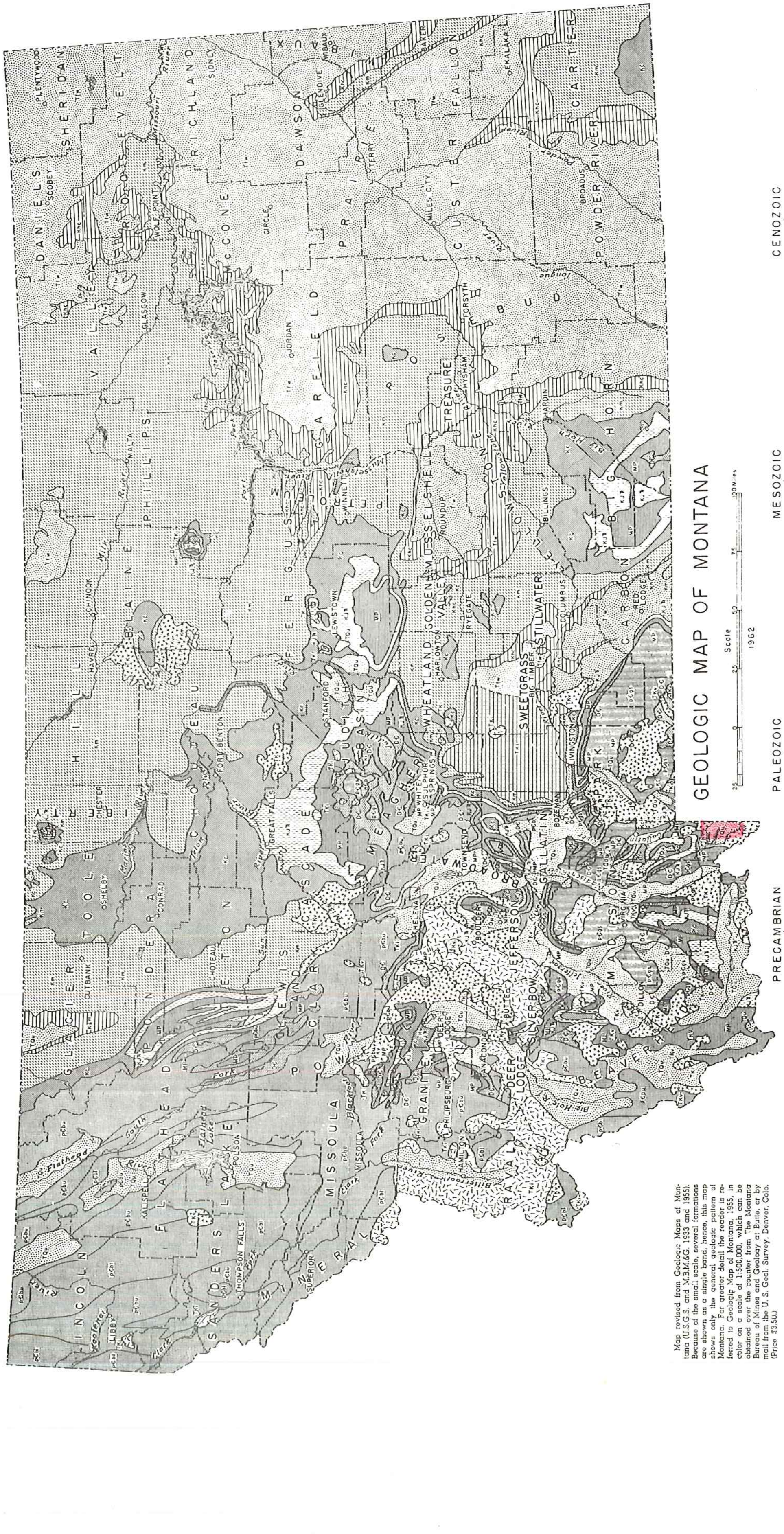
The proposed tasks will augment the work being conducted by others: (1) the geologic investigation of controls on hot-spring occurrences by Dr. R. A. Chadwick and students (Montana State University); (2) the study of mine-water temperatures and geothermal potential of the Upper Centennial Valley (MBMG); and (3) the evaluation of geothermal potential in western Montana by Robert Leonard (U.S. Geological Survey).

Need for Study and Objectives:

State and federal agencies are attempting to develop an adequate resource information base to evaluate the quality and quantity of geothermal resources, with the goal of producing geothermal resource potential maps and providing site-specific reports to the appropriate local government groups. The proposed tasks would provide the following types of information:

(1) A detailed report on the West Yellowstone KGRA. This is Montanas oldest KGRA, yet state and federal organizations have not attempted to define the geothermal resource in this area adjacent to Yellowstone National Park. West Yellowstone has a fairly large permanent population and is a winter resort area. We believe that this area has the best potential for geothermal energy development, for space heating purposes, in Montana. The area to be investigated is shown in Figure 1.

Figure 1. Location map



EXPLANATION

SEDIMENTARY ROCKS

CENOZOIC

TQu, Tfw

TQu, Tertiary sediments, Willow Cr. fm, glacial deposits, and alluvium in western Montana.
Tfw, Fort Union, Flaxville, Wasatch, and White River fms in central and eastern Montana.

TKl

TKl, Livingston fm of Crazy Mts. area; includes Montana group above Eagle ss, Hell Cr., and Fort Union fms.

MESOZOIC

Ksm, Khc

Ksm, St. Mary River formation of north-central Montana.
Khc, Hell Cr. fm, central and eastern Montana.

Km

Km, Montana group: Telegraph Creek, Eagle, Claggett, Judith River, and Bearpaw fms over most of state; Fox Hills ss and Pierre sh. in extreme east.

Kc

Kc, Colorado group: Thermopolis, Mowry, Belle Fourche, Greenhorn, Carlile, and Niobrara formations in south-central and eastern Montana, and the Blackleaf fm and Marias River shale of north-central Montana.

KJTR

KJTR, Lower Mesozoic Ellis group, Morrison formation, and Kootenai fm. Includes Triassic Dinwoody where present.

PALEOZOIC

MP

MP, Mississippian, Pennsylvanian, and Permian fms: Madison group, Big Snowy group, Amsden, Quadrant-Tensleep, and Phosphoria formations.

D€

D€, Devonian and Cambrian formations: Flathead, Wolsey, Meagher, Park, Pilgrim, Red Lion, Maywood, Grove Cr., Jefferson, and Three Forks formations.

PRECAMBRIAN

p€b, p€bu, p€bl

p€b, Belt formations undifferentiated.
p€bu, Upper Belt formations of the Piegan and Missoula groups.
p€bl, Lower Belt formations of the Ravalli group and the Prichard formation.

p€gs

p€gs, Pre-Belt gneisses, schists, marbles, and associated rocks of the Cherry Creek series, pre-Cherry Cr. fms, and the Stillwater igneous complex.

IGNEOUS ROCKS

TKv

TKv, Volcanic Rocks

TKi

TKi, Intrusive Rocks

Study Area

(2) Several communities have geothermal resources which may warrent development. State support is available through Montana's Renewable Energy Resources Program. We propose to compile all existing data and to provide additional geological and geophysical information in order to produce reports for these communities, evaluating the geothermal potential and recommending test drilling sites for defining the resource and its development feasibility. A tentative list of study site areas includes: Warm Springs State Hospital, Broadwater, White Sulphur Springs, Boulder, Silver Star, and Norris.

(3) Ground-water analyses collected by the U.S. Geological Survey and MBMG have not been entered in state or federal data files. We propose to start with current analytical data and work back to older data, checking all information about source, location, etc., and getting this data base entered in the state and federal (ie. U.S.G.S. W.R.D.) data banks. This will provide a minimum of 2,500 new entries which can be evaluated for the Geotherm data file and the Montana geothermal resource map (to be prepared by N.O.A.A.).

(4) The enclosed table of thermal springs has 78 entries at present. For some of these springs, adequate discharge information is lacking, while others need both temperature and discharge measurements. We propose to measure (or remeasure) temperature, discharge, specific conductance, and pH at all thermal springs not studied by the U.S.G.S. investigators, to check for thermal springs at additional locations, and to inventory shallow ($<$ 1,000 ft.) warm water wells and Bendix's uranium exploration holes, thereby improving the resource data base.

Methods of Investigation:

I. West Yellowstone Area

A. Field Procedures:

1. Locate springs and wells within the study area.

2. Determine in the field: temperature, flow (springs) or yield (wells), specific conductance, pH, and silica content for wells and springs.

3. Measure stream flows and estimate the thermal and non-thermal contribution to base flow.

4. Study in detail the geology of areas suspected to contain geothermal cells.

5. Collect samples for standard chemical analysis.

6. Collect special samples for detailed chemical analysis.

B. Office and Laboratory Procedures:

1. Examine maps and aerial photographs to locate all identifiable wells and springs.

2. Determine the chemical quality of spring and well waters.

a. Standard analyses include the determination of: Ca, Mg, Na, K, Fe, Mn, SiO_2, Al, HCO_3, CO_3, Cl, SO_4, F, pH, and specific conductance.

b. Special analyses include all determinations in the standard analyses plus: NH_3, Sb, B, Li, Sr, As, Hg, U, Se, Br, I, and H_2S.

3. Plot well and spring locations on base maps. Contour overlay maps based upon water chemistry and geochemical calculations of equilibrium (at depth) water temperatures using silica and K-Na-Ca geothermometery models.

4. Code all data for input to state and federal data systems.

5. Compile and integrate data with related ongoing research projects.

6. Calculate the volume of thermal waters within each identified geothermal cell.

7. Develop initial models to describe the physical, thermal, chemical, and hydrologic conditions in the study area.

8. Test drilling to test hypotheses and evaluate geothermal potential.

9. Write a final report on the study, which will include the following: the quantities of energy in each of the cells, the annual rate of natural dissipation of this energy, and a ranked list of high-potential sites within the study area, should the results indicate significant geothermal energy reserves.

II. Other Areas

A. Field Procedures:

1. Provide detailed geologic mapping in the vicinity of hot spring areas, augmented with geophysical data where feasible.

2. Measure temperature and specific conductance with a Yellowsprings model 33 Salinity-Conductivity-Temperature meter, measure discharge (flow) with a flow meter, and measure pH with a Digi-Sense model 5985-40 or equivalent pH meter. Collect selected spring samples for standard analysis.

3. Check thermal spring and well locations and elevations.

B. Office and Laboratory Procedures:

1. Collection and synthesis of existing geological and geophysical data.

2. Determine the chemical quality (standard analysis) of previously unsampled thermal springs and wells.

3. Checking for errors and coding ground-water chemical analysis information on proper format for entry into state and federal data systems.

Update thermal well and spring data base, draft maps, figures, etc., and write reports to the appropriate local, state, and federal agencies.

4. Obtain heat flow measurements if feasible from the uranium test holes to be drilled in the Missoula and Bitterroot valleys.

Note on Personnel, Funding, Laboratory Facilities, and Work Schedule:

Professional resumes are presented in Appendix I. The Bureau is currently accepting applications for a hydrologist position to work on the West Yellowstone study. Experience and interest in geothermal research will be the major criteria in hiring this man.

Dr. Sonderegger is currently matching 3½ months salary over the next 2½ years as principal investigator on a geothermal research project entitled "A reconnaissance study of geothermal potential in the upper parts of Red Rock Creek and Madison River valleys, southwestern Montana", which is scheduled to terminate September 30, 1979, and in the process of completing a final report on "A study of mine water temperatures in hardrock mining districts of Montana", a project scheduled to terminate May 15, 1978. Both of these projects are funded under contract EY-76-S-06-2426. No conflict with time available or duties is foreseen.

Budget requirements for the proposed tasks are presented in Appendix II. Graduate students will be utilized to assist Bermel (task no. 1) and Bergantino (tasks 2-4) where possible; however, such students will be closely supervised by permanent staff members. Travel and per diem were calculated assuming 480 man days in the field ($30,000), plus the travel expenses to meetings to present research results. Matching funds represent two man months per fiscal year for Sonderegger and one man month per fiscal year for Bergantino.

Laboratory instrumentation includes:

- 1 Model AA-4, Varian Techtion Atomic Absorption Spectrophotometer
- 1 Model 403, Perkin Elmer Atomic Absorption Spectrophotometer with background correction and auto-sample changer
- 1 Model 503, Perkin Elmer Atomic Absorption Spectrophotometer with background correction and graphite furnace
- 1 Model S/N243, Spectrometrics Co. Plasma Source Echelle Spectrometer with qualitative comparator attachment

The laboratory has consistently done well on USGS interlaboratory standards for the last five years, and analyzes all ground-water samples collected in Montana by the USGS Water Resources Division.

The project work plan and scheduling may be briefly summarized as follows: (a) spring of 1978, organize base maps, photos, etc., locate key points for stream flow gauging, review existing maps and data; (b) summer-fall 1978, reconnaissance field work and basic data collection in West Yellowstone, initiation of measurement studies at known thermal springs and wells, study of two or three of the community hot spring sites, and initiation of the computer processing of ground-water data; (c) winter-spring 1978-79, compilation of data, report writing, laboratory analyses, data coding, etc.; (d) summer-fall 1979, completion of basic field work and drilling in West Yellowstone, geothermal gradient work in Missoula and Bitterroot valleys, one or two community resource studies, continue thermal spring measurements, ground-water data coding, etc.; winter-spring 1979-80, compile field results, write first draft of Yellowstone report, laboratory analyses, data coding, drafting, etc.; summer-fall 1980, final field work in West Yellowstone (stream gauging checks on interpretations in first draft) and writing final draft; completion of thermal spring inventory, data processing and community studies, submission of all reports.

A schedule of projected expenditures of federal funds is presented to facilitate understanding of the total program of geothermal research being conducted by the Montana Bureau of Mines and Geology with support from the Geothermal Branch of the U.S. Department of Energy.

STUDY	FY 78	FY 79	FY 80
Hard Rock Study	committed 77		
Red Rock Area	52,000	34,400	
Supplementary Studies	48,000	80,600	135,000*

*50,000 drilling costs expected to be paid in October, 1979.

APPENDIX I

Professional Resumes

June, 1977

RESUMÉ

Name: John Lawrence Sonderegger II
Born January 14, 1942, Madison, Wisconsin
Married, three children

Education:

B.S.I. - Geology, 1962-1966, University of Wisconsin
M.S. - Geology, Fall 1966, University of Tennessee[1], 1967-1969, University of Alabama
Ph.D. - Geochemistry, 1969-1970, Northwestern University[2], 1970-1973, New Mexico Tech[3]

Academic Honors:

University of Wisconsin - Instate Tuition Scholarship 1963-1966
Northwestern - N.D.E.A. Fellowship

Work Experience:

Montana Bureau of Mines and Geology - Research Assistant Professor and Hydrogeologist- December 1974 to present.
Georgia Earth & Water Division - Geologist II - 1973-1974; Geologist III - 1974 to December 1974.
Geological Survey of Alabama - ¾ time as Geologist I - 1967-1969.

M.S. Thesis:

A photogeologic and structural study of a limestone terrane with emphasis on fractures affecting ground-water occurrence.

Ph.D. Dissertation:

A preliminary investigation of the dissolution kinetics of strontianite and witherite.

Publications:

Sonderegger, J. L., 1968, Geology of the Athens quadrangle, Alabama (abs): Jour. Alabama Acad. Sci., v. 39, no. 3, p. 211.

_______1969, Calculation of carbon dioxide partial pressure from chemical analyses of limestone ground water: Jour. Alabama Acad. Sci., v. 40, no. 4, p. 227-231.

_______1970, Hydrology of limestone terranes-photogeologic investigations: Geol. Survey Alabama Bull. 94-C, 27 p.

_______1974, Effect of Chattanooga shale facies distribution on the in situ formation of negative structures by ground-water solution (abs): Geol. Soc. America Abs. with Programs, v. 6, no. 4, p. 399.

_______1974, A preliminary investigation of strontianite dissolution kinetics (abs): Geol. Soc. America Abs. with Programs, v. 6, no. 7, p. 961.

_______1976, Hydrologic and geochemical controls on tailings pond drainage affecting Soda Butte Creek, Cooke City, Montana (abs): Geol. Soc. America Abs. with Programs, v. 8, no. 5, p. 634.

_______A tentative exploration model for the location of oxidized uranium deposits in fluvial sandstone: submitted to Econ. Geology.

_______and Billings, G. K., 1971, The geochemical cycle of molybdenum (abs): Geol. Soc. America Abs. with Programs, v. 3, no. 7, p. 712-713.

_______Brower, K. R., and LeFebre, V. G., 1976, A preliminary investigation of strontianite dissolution kinetics: Am. Jour. Sci., v. 276, no. 8, p. 997-1022.

_______and Kelly, J. C., 1970, Hydrology of limestone terranes-geologic investigations: Geol. Survey Alabama Bull 94-B, 146 p.

_______and Miller, M. R., 1977, Preliminary results of investigations on leachable salt loads in saline seep areas of Montana (abs): Geol. Soc. America Abs. with Programs, v. 9, no. 6, p. 764-765.

_______Pollard, L. D., and Cressler, C. W., 1977, An atlas of Georgia's ground-water quality: Georgia Dept. Nat. Resources, in press.

_______Wallace, J. J., Jr., and Higgins, G. L., Jr., 1976, Acid mine drainage control-feasibility study, Cooke City, Montana: Montana Bur. Mines and Geol. Open-File Report 23, 197 p.

Bergantino, R. N., Groff, S. L., Norbeck, P. M., Smith, D. J., Sonderegger, J. L., Coffin, D. L., Feltis, Richard, Van Voast, W. A., Hedges, R. B., and McDermott, J. J., 1976, Ground water of the Fort Union coal region, Montana: Montana Bur. Mines and Geol. Preliminary Report-1977 Montana Legislature, 39 p.

Billings, G. K., and Sonderegger, J. L., 1971, The geochemical cycle of molybdenum in our environment (abs): Am. Chem. Soc., Div. Water, Air and Waste Chem., Ann. Mtg., Washington, D. C.

Billings, G. K., Beane, R. E., Sonderegger, J. L., and Hayslip, D. L., 1972, Phase I: Qualitative mineralogical analysis and quantitative chemical analysis of selected shale samples from the Lyons, Kansas, nuclear-waste burial site: Oak Ridge Natl. Lab. Contract Research Report for Subcontract No. 3673, 22 p.

Miller, M. R., Bermel, W. M., Bergantino, R. N., Sonderegger, J. L., Norbeck, P. M., and Schmidt, F. A., 1977, Compilation of hydrogeological data for southeastern Montana: Montana Bur. Mines and Geol. Spec. Rept. to the Yellowstone-Tongue A.P.O., 295 p.

Norbeck, P. M., and Sonderegger, J. L., 1976, Ground-water investigation of Columbia Gardens II site: Montana Bur. Mines and Geol. Open-File Report 22, 16 p., 15 fig.

Wallace, J. J., Jr., Sonderegger, J. L., and Higgins, G. L., Jr., 1975, Annual report: Acid mine drainage control-feasibility study, Cooke City, Montana: Report to Montana Department of Natural Resources for E.P.A. Grant No. S-802671, 39 p.

Work in Progress:

Determination of soluble salt loads in glacial deposits and weathered Cretaceous formations, and interpretation of hydrochemical factors relating to saline seep in Montana.

A reconnaissance study of mine-water temperatures in hardrock mining districts of Montana.

A reconnaissance study of the geothermal potential of the upper Centennial Valley, Montana.

Research Interests:

1. Field and laboratory studies of mineral-aqueous interactions which affect ground-water composition.

2. The use of ground-water chemistry in the evaluation of geothermal and uranium resource potential.

[1] Left for financial reasons.
[2] Left because of faculty changes in geochemistry.
[3] Degree granted in 1974.

November, 1977

RESUMÉ

Name: Robert Nicholas Bergantino
Born June 14, 1940, Glasgow, Montana
Married, one child

Education:

A.S. - Engineering - North Dakota State School of Sciences, 1958-1960
B.S. - Geology - University of Montana, 1960-1961, 1962, 1966-1967

Academic Honors:

N.D.S.S.S. - Freshman Mathematics Achievement Award
University of Montana - Outstanding Geology Senior. Graduated Cum Laude (3.29/4.0, 209 quarter hours)

Work Experience:

Montana Bureau of Mines and Geology - Research Assistant Professor and Hydrogeologist - October 1974 to present
U.S. Naval Oceanographic Office, Washington, D. C. - Geological Oceanographer - 1968 to 1974

Publications:

Submarine regional geomorphology of the Gulf of Mexico, 1971, Bull. Geological Society of America, v. 82, p. 741-752.

Geology and genesis of the Mexican Ridges: western Gulf of Mexico, 1973, Journal of Geophysical Research, v. 78, no. 14, p. 2498-2507.

Ground water of the Fort Union coal region, Montana, 1976, Montana Bureau of Mines and Geology, Report to the 1977 Legislature.

Geology of the Forsyth 1 degree by 2 degree sheet, April 1977, scale 1:250,000, Montana Geologic Atlas.

Geology of the Hardin 1 degree by 2 degree sheet, April 1977, scale 1:250,000, Montana Geologic Atlas.

Geology of the Ekalaka 1 degree by 2 degree sheet, April 1977, scale 1:250,000, Montana Geologic Atlas.

Geology of the Miles City 1 degree by 2 degree sheet, April 1977, scale 1:250,000, Montana Geologic Atlas.

Compilation of hydrogeologic data for southeastern Montana, Montana Bureau of Mines and Geology, Open File Report, April 1977.

Compilation of well data for southeastern Montana, Montana Bureau of Mines and Geology, Open File Report, August 1977.

Research Interests:

Fluvial and glacial geomorphology, sediment depositional processes, remote sensing applications to geology and hydrology, weather and climate modification.

RESUME'

Personal:

Wesley Martin Bermel
Born April 8, 1952, Williston, North Dakota
Married, one child

Education:

B.S. - Geological Engineering (June, 1976), Montana College of Mineral, Science, and Technology

Professional organizations:

Junior member, American Association of Petroleum Geologists
Member, Tobacco Root Geological Society

Work Experience:

Currently employed by the Montana Bureau of Mines and Geology, Hydrology Division, as a Hydrotechnician (classified June, 1975).

My non field season work assignments include: 1.) To review subdivision environmental impact statements and make comments on the subdivision with respect to its effects on ground and surface water as well as potential flood danger. 2.) To supervise six (6) student assistants which are presently collating all existing water quality information in the Fort Union Coal Region. 3.) To supervise one (1) student who is presently doing some of Hydrology Division's computer programming and to control system design, computer programming and system analysis for the division and entire Bureau. 4.) To construct plane table maps of hydrologic test areas. 5.) To produce photographic materials such as black-and-white prints and color slides for Division use. My field season duties include: 1.) To perform routine technical work in collecting and processing geological data and materials; a.) Specific conductivity surveys of ground and surface water; b.) Well inventorying and monitoring; c.) Aquifer testing. d.) Plane surveying in locations and elevation of research sites. 2.) Investigation of geothermel potential in the Centennial Valley; a.) Well and spring inventory; b.) Field measurement of silica and fluoride to determine whether or not to resample for a complete analysis including major anions and cations plus some trace elements; c.) Maping areas with no geology previously mapped; d.) Measuring sections of volcanic flows (pulses) in area.

Presently, I am one of several whom are supervising the collating of all ground-water information of the Fort Union Coal Region in Montana.

Preceding June, 1975, I was also employed by the Montana Bureau of Mines and Geology, Hydrology Division, as a student assistant; my responsibilities were centered around the supervision of coding Water Quality Data. However, my main job was to write, revise, and update the Hydrology Division's programs. Associated with the programming, I was also involved in the developing of several Data Systems. Alsong with these responsibilities I also monitored our test wells throughout the state.

Other work done with the Bureau also includes two (2) years of work assiociated with the Silver Bow Creek drainage study. This involved water quality sampling, measuring field parameters such as pH, specific conductivity, EH, turbidity, and stream flow measurements.

During the summer of 1973, I was employed by the Anaconda Copper Mines Company where my job consisted of taking samples at drill rig sites, using a spitter, then sending them in to be analysed. Also, I split core when necessary.

Major Accomplishments Included:

Water Quality Data System
Printer Plot Routine
Water Level Program and Data Base
Well Appropriation Data Base and Associated Programs

Open File Reports:

Bermel, W. M., 1974, Conversion of Section-Township-Range to Latitude-Longitude.

______________, 1973, Mineral Identification, Question Answer Documentation.

______________, 1974, Recording on the IBM 1311 Disk System.

______________, 1974, Storage Data Preparation for Lat-long.

Bergantino, Robert, Bermel, W. M. , 1975, Montana Geological Maps of Southeastern Montana at 1:250.000 scale.

Miller, Bermel, Bergantino, Sonderegger, 1977, Compilation of Hydrogeological Data For South Eastern Montana

____________________, 1977, Well Appropriation Data for South Eastern Montana.

__________, Sonderegger, Glasser, 1977, A Reconnaissance Study of Geothermal Potential In the Upper Parts of Red Rock Creek and Madison River Valleys, Southwestern Montana, Preliminary Results, Open File Report 25.

References:

Dr. John Sonderegger	Montana Bureau of Mines and Geology West Park Street Butte, MT 59701 (406) 792-8321, ext. 241	Hydrogeologist
Dr. Fred Earll	Montana Tech West Park Street Butte, MT 59701 (406) 792-8321, ext. 269	Head of Geology Department
Dr. Hugh Dresser	Montana Tech West Park Street Butte, MT 59701 (406) 792-8321, ext. 268	Professor in Geology Department

APPENDIX II

Project Budget
May 1, 1978-September 30, 1980

		Federal	State
A.	Salaries, Wages, and Benefits		
	P.I. (Sonderegger; 2,2,4)	$ 4,386	$11,452
	Hydrologist (Bergantino; 4,7,7)	24,919	4,920
	Hydrologist (Bermel?; 5,6,8)	24,128	
	Technicians and students	15,000	
	Total Salaries	68,433	16,372
	Benefits*	10,265	2,456
	Salaries plus Benefits	$ 78,698	$18,828
B.	Travel and Per Diem (480 days at $62.50--assuming 150 miles/day at $.25/mile)	32,400	
C.	Field Equipment, Supplies, and Research Materials	2,750	
D.	Drilling Costs (2,000 ft. @$25/Ft.)	50,000	
E.	Computer Applications (includes 2,500 back analyses @$16)	41,500	
F.	Report Costs	5,050	
G.	Laboratory Water Analyses	12,000	
H.	Contingencies	5,000	
I.	Indirect Costs (46% of A)	36,201	8,661
J.	Total Costs	$263,599	$27,489

*Currently 13.5% of salaries but expected to rise with new social security legislation. The cost was calculated assuming an average cost of 15%; however, only the actual costs will be charged against the project.

Method of Payment

Payment in full will be $263,599, which may be made according to standard ERDA accounting procedures.

Approval Signatures

Submitted by:

Mr. Marvin R. Miller
Chief, Hydrology Division
Montana Bureau of Mines and Geology

Dr. John L. Sonderegger
Hydrogeologist
Montana Bureau of Mines and Geology

Approved by:

Dr. S. L. Groff
Director and State Geologist
Montana Bureau of Mines and Geology

Dr. Vernon Griffiths
Director of Research
Montana College of Mineral Science and Technology

Mr. David Crockett
Geothermal Energy Branch
U.S. Department of Energy

PRELIMINARY LIST OF THERMAL SPRINGS IN MONTANA
BY THE MONTANA BUREAU OF MINES AND GEOLOGY
(Compilation by R. N. Bergantino and J. L. Sonderegger, November, 1977)

NAME	LOCATION T	R	S	tract	TEMPERATURE °C	°F	FLOW l/min	gpm	cfs	TOPOGRAPHIC MAP	ALTITUDE meters	feet	APPARENT SOURCE OF WATER		SAMPLED BY agency	date	WATER CHEM. DATA sc@25°C	pH	Stan. Anal.
Alhambra	8N	3W	16	ACAA	56.5		40			Clancy 15'	1330	4360	Boulder batholith		USGS*	08-23-74	929	7.23	Yes
						131		150-250							MBMG	09-01-72	192	7.83	Yes
Anaconda	3 miles east of Anaconda ?									Anaconda 15'									
Andersons	3S	13E	29	ABAB		77				McLeod Basin 7.5'	1690	5540	Madison		MBMG	07-25-72	414	7.84	Yes
Andersons Pasture	13S	2W	18	ACD	23.5-28				2.0	Lower Red Rock Lake 15'	2085	6840	Pleistocene volcanics	2 springs	MBMG*	10-03-77	609	7.4	Yes
Apex	5S	9W	10	AADADD						Glen 7.5'	1600	5240							
Barkells	2S	6W	1	CBD	71.5		150			Twin Bridges 15'	1430	4700	Boulder bath.		USGS*	08-18-74	808	8.17	Yes
						162		150							MBMG	07-10-72	847	8.40	Yes
Bear Creek	9S	9E	19	DB		90		30		Gardiner 15'	1700	5600	Madison						
Bearmouth 1	11N	14W	11	DCCCD						Bearmouth 15'	1170	3840	Madison						
Bearmouth 2	11N	13W	18	AB	15					Bearmouth 15'	1173	3850	Madison		USGS	03-18-72	610	7.69	Yes
Beartrap (see Norris)																			
Beaverhead Rock	5S	7W.	22	ABBD		81		100		Beaverhead Rock 7.5'	1470	4810	Tertiary sed. over Madison (?)						
Bedford	7N	1E	23	ABBC		74		1200-1500		Townsend 15'	1180	3880	Precambrian Spokane Fm.		Health	12-09-64	TDS 266	N.D.	No
Big Hole (see Jackson)																			
Big Warm Springs (see Lodgepole 1,2,3)																			
Big Warm Springs (see Brooks)																			
Birch Creek (see Apex)																			
Blue Joint 1	2S	23W	1	A		84			0.6	Painted Rocks Lake 15'	1535	5040	Idaho bath.; Precambrian Ravalli		MBMG	08-11-72	162	8.12	Yes
Blue Joint 2	2S	22W	6	BA		85			0.5	Painted Rocks Lake 15'	1505	4940	Idaho bath.; Precambrian Ravalli		MBMG	08-11-72	180	8.22	Yes
Boulder	5N	4W	10	C	62; 76					Boulder 15'	1480	4850	Boulder bath.		USGS*	08-22-74	523	8.50	Yes
						100		250							Health	11-24-64	TDS 388	N.D.	No
Bozeman	2S	4E	14	DDBAA	50			inactive		Bozeman 15'	1443	4735	pre-Belt		USGS*	08-25-74	624	8.58	Yes
						130-135	(former flow 60 gpm)								Health	1964	TDS 428	N.D.	No
Brewers (see White Sulphur Springs)																			
Broadwater	10N	4W	28	A	62		< 50			Helena 15'	1250	4100	Belt and Boulder bath.		USGS*	08-24-74	796	8.53	Yes
						138		75							Health	09-17-64	TDS 563	N.D.	No

NAME	LOCATION T	R	S	tract	TEMPERATURE °C	°F	FLOW l/min	gpm	cfs	TOPOGRAPHIC MAP	ALTITUDE meters	feet	APPARENT SOURCE OF WATER	SAMPLED BY agency	date	WATER CHEM. DATA sc @ 25°C	pH	stan. anal.
Brooks	17N	18E	19	DBDBB		70		80000		Lewistown 15′	1145	3760	Kootenai;Madison	Health	08-19-64	TDS 670	N.D.	No
						68								MBMG	08-17-73	1754	7.92	Yes
					19.5				151					USGS	09-23-75	882	7.68	Yes
Browns	8S	9W	30	DCB	23				7.6	Dalys 7.5′	1700	5575	Madison; Tert. volc.	MBMG	09-06-77	618	N.D.	No
Byrnes (see Nimrod)																		
						110-114								MBMG	11-24-64	TDS 270	N.D.	No
Camas	21N	24W	3	BBB	45		> 200			Hot Springs 7.5′	860	2830	Piegan; Diorite sill	USGS*	07-03-75	367	9.39	Yes
					44									USGS	09-15-75	394	9.11	Yes
Chico	6S	8E	1	CDCD	42		> 500			Emigrant 15′	1610	5280	Tert. sed. w/Tert. granite and Madison	USGS*	08-25-74	379	7.38	Yes
						119								MBMG	11-24-64	TDS254	N.D.	No
Clarks (see Potosi 1)																		
Cliff Lake (see W. Fk. Swimming Hole)																		
Corwin (see La Duke)																		
Diamond Bar Inn (see Jackson)																		
Diamond S (see Boulder)																		
Durfee Creek 1	12N	22E	13	DDD		66		.75		Roundup 1° x 2°	1400	4600	Madison; Pennsylvanian	MBMG	08-15-73	2535	8.08	Yes
Durfee Creek 2	12N	23E	19	BB		71		15000		Roundup 1° x 2°	1550	5100	Madison; Pennsylvanian					
Elkhorn	4S	12W	29	ACAD	48.5		400			Polaris 15′	2190	7200	Boulder bath.	USGS*	08-20-74	209	8.94	Yes
						114		450						MBMG	07-27-72	219	8.49	Yes
Emigrant Gulch (see Chico)																		
Ennis	5S	1W	28	DCAD		172		15		Ennis 15′	1500	4920	Tert. sed. over pre-Belt (T.R. Stock?)	Health(?)	02-06-69	TDS 310	N.D.	No
Fairmont (see Gregson)																		
Ferris (see Bozeman)																		
Flat Mountain	15N	20E	6				stopped flowing in the early 1900′s			Judith Peak 15′	1675	5500						
Gallatin Canyon	6S	4E	33							Garnet Mountain 15′	1830	6000	Madison					
Gallogly	1S	19W	15	BCCCAC		100		120		Lost Trail Pass 7.5′	1645	5400	Idaho bath.	Health	08-05-64	TDS 144	N.D.	No
						120		120						MBMG	08-10-72	202	7.81	Yes

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Garrison	10N	9W	19	A		77				Garrison 15′	1495	4900	Cretaceous-near Madison	MBMG	08-08-72	737	7.30	Yes
Giant Springs	21N	4E	33	BDAC		53			605	Northeast Great Falls 7.5′	988	3240	Kootenai; Madison	N.D.	03-20-53	TDS 410	7.5	No
Granite	11N	23W	7	ABDBA		126		50		Lolo Hot Springs 7.5′	1275	4180	Wallace; Idaho bath.					
Green Springs	20N	24W	33	ADDD		66				Perma 15′	860	2820	Alluvium;Precambrian Piegan	MBMG	1964	TDS 162	N.D.	No
Gregson	3N	10W	2	BDCA	70		1000			Anaconda 15′	1565	5130	Tert. volc.;Boulder bath.	USGS*	08-19-74	761	8.41	Yes
						154								Health(?)	04-08-65	TDS 560	N.D.	No
Hapgood (see Norris)																		
Helena (see Boradwater)																		
Hunters	1S	12E	9	CCADC	59 (ave)		5000			Hunters Hot Springs 7.5′	1335	4380	Livingston; Cret. volc.; Tert. granite	USGS*	07-02-75	354	9.13	Yes
						150		1500						MBMG	07-25-72	387	8.52	Yes
Jackson	5S	15W	25	CBBB		134				Jackson (advance) 7.5′	1970	6470	Alluvium;Tert. sed.; Missoula	MBMG	08-06-64	TDS 662	N.D.	No
														MBMG	07-28-72	1020	9.04	Yes
					58		>1000							USGS*	08-16-74	972	6.77	Yes
Jardine (see Jackson)																		
Kimpton (see Warner)																		
La Duke	8S	8E	32	CDBA	65		500			Miner 15′	1610	5280	Madison	USGS*	07-02-75	2460	6.52	Yes
						151		500						MBMG	07-26-72	2400	7.62	Yes
La Hood Park	1N	3W	12	ACA		66		4		Jefferson Island 15′	1430	4700	Precambrian near Madison					
Landusky 1	25N	24E	32	DABCC		70		600		Hays 7.5′	1130	3710	Madison; Jurassic	MBMG	08-16-73	801	8.03	Yes
Landusky 2	25N	24E	32	DACAAA						Hays 7.5′	1130	3710	Madison; Jurassic					
Landusky Plunge	24N	24E	12	CDDAB		76		3000		Hays SE 7.5′	1125	3690	Madison; Jurassic	MBMG	08-16-73	1262	8.09	Yes
Lithia (see Andersons)																		
Little Warm Springs 1	26N	26E	30	DABD						Bear Mountain 7.5′	1085	3560	Madison; Jurassic					
Little Warm Springs 2	26N	26E	32	ACAAA		79		1200		Bear Mountain 7.5′	1025	3360	Madison; Jurassic	MBMG	08-16-73	2082	8.06	Yes
						72		5000						MBMG	05- 1977	N.D.	N.D.	No
Little Warm Springs 3	26N	26E	32	ADB	22.5					Bear Mountain 7.5′	1025	3360	Madison; Jurassic	USGS	10-04-73	1823	7.92	Yes
Lodgepole 1	26N	25E	24	CAAD	} 26	} 87		} 2700		Bear Mountain 7.5′	1100	3600	Madison	} analysis by USGS & MBMG-- identification of spring not clear				} Yes
Lodgepole 2	26N	25E	24	CABD						Bear Mountain 7.5′	1125	3700	Madison					
Lodgepole 3	26N	25E	24	DBC						Bear Mountain 7.5′	1100	3600	Madison					

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Lolo	11N	23W	7	ADCCC	44		100			Lolo Hot Springs 7.5′	1266	4155	Wallace; Idaho bath.	USGS*	08-17-74	225	9.27	Yes
						112		50						MBMG	08-09-72	234	7.87	Yes
Lost Trail (see Gallogly)																		
Lovells	8S	9W	28	BD		72		1125		Gallagher Mountain 7.5′	1675	5490	Tert. sed.; Tert. volc.; Madison					
Mc Menomey Ranch	9S	10W	29	AAA						Dalys 7.5′	1660	5449						
Matthews (see Bozeman)																		
Medicine	1N	20W	12	CCA		120		100		Medicine Hot Springs 7.5′	1355	4440	Idaho bath.	Health	08-05-64	TDS 170	N.D.	No
								100						MBMG	08-09-72	377	8.08	Yes
					45		400							USGS*	08-16-74	343	8.59	Yes
Medicine (see Gallogly)																		
Medicine (see Sun River)																		
Medicine Lodge	12S	11W	7	ABDDD						Deer Canyon 7.5′	2010	6595	Madison					
Medicine Rock (see Sleeping Child)																		
Mockels (see Plunkets)																		
Montanapolis	6S	10E	29	AAC						Emigrant 15′	1805	5920	Tert. granite; Madison; Cambrian	MBMG	1964	TDS 3264	N.D.	No
Morrison Butte (see Landusky Plunge)																		
Naves (see Plunkets)																		
New Biltmore	4S	7W	28	BDA		126		100		Beaverhead Rock 7.5′	1458	4783	Madison	MBMG	08-06-64	TDS 2004	N.D.	No
						130		100						MBMG	07-10-72	2140	7.34	Yes
					53		> 100							USGS*	08-17-74	2160	6.76	Yes
New Biltmore "Cold Spring"	4S	7W	28	ACBC		62		8		Beaverhead Rock 7.5′	1458	4783	Madison					
Nimrod	11N	15W	14	CDAA		72		200		Bearmouth 15′	1160	3800	Cambrian; Madison	Health	08-03-64	TDS 722	N.D.	No
					19									USGS	03-18-72	856	7.63	Yes
Nissler Junction	3N	8W	19	BA			stopped flowing circa. 1920			Butte North 15′	1640	5375	Tert. Sed.; Boulder bath.					
Norris	3S	1W	14	DAB	52.5		400			Norris 15′	1465	4805	Pre-Belt; Tobacco Root Stock	USGS*	08-21-74	903	7.58	Yes
														MBMG	11- 1964	TDS 620	N.D.	No
						124	88							Private	05-04-70	TDS 700	N.D.	No

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Thexton (see Ennis)																		
Toston	4N	3E	6	DADC		57			20	Toston 15′	1205	3960	Pennsylvanian; Madison	MBMG	11-24-64	TDS 238	N.D.	No
Trudau	7S	4W	7	DCACCC						Metzel Ranch 7.5′	1730	5675						
Tyler 1&2 (see Durfee Creek 1&2)																		
Vigilante	9S	3W	22	BDDD		> 90		500-1500		Varney 15′	1890	6200	Madison; Kootenai					
Warm Springs-State Hospital	5N	10W	24		77		600			Anaconda 15′	1470	4820	Boulder bath. (?)	USGS*	08-19-74	1510	6.46	Yes
						160		60						MBMG	04-08-65	TDS 1308	N.D.	No
Warm Springs (see Medicine Lodge)																		
Warm Springs (see Landusky Plunge)																		
Warner	5N	1E	22	DBBC		65				Radersburg 15′	1250	4100	Alluvium; Tert. sed.; Precambrian	MBMG	08-29-72	929	8.84	Yes
Weeping Child (see Sleeping Child)																		
West Fork Swimming Hole	12S	1E	18	CAD	25-28				1.1	Cliff Lake 15′	2040	6700	Alluvium; Pleistocene volc. (?)	MBMG*	09-29-77	322	8.30	Yes
White Sulphur Springs	9N	7E	18	BB		95-125 ?		500		White Sulphur Springs 7.5′	1530	5025	Tert. sed.; Precambrian	MBMG	09-01-61	TDS 1450	N.D.	No
					46		>1500							USGS*	08-17-74	2220	6.8	Yes
Wolf Creek	10S	1E	9	BBBA	54-66				0.7	Cliff Lake 15′	1860	6100	Tert. sed.; Precambrian	MBMG*	09-30-77	494	11.03	Yes
Ziegler (see Apex or New Biltmore)																		

*Symbol after analysis indicates a preferred analysis, conducted for geothermal evaluation, with a field (rather than laboratory) pH measurement.

A standard analysis includes: Ca, Mg, Na, K, Fe, Mn, SiO_2, CO_3, HCO_3, SO_4, Cl, F, NO_3, pH, and specific conductance.

Flow values and chemistry for some springs may not agree because of multiple sampling; some questionable values have been included.

Abbreviations:

Health, Montana State Board of Health
MBMG, Montana Bureau of Mines and Geology
USGS, United States Geological Survey
N.D., Not determined
T.R., Tobacco Root