GL01106

Open-File Report
ID/BHS/ESL-1

Original

A GEOTHERMAL RESOURCE SITE EVALUATION NEAR BANBURY HOT SPRINGS - TWIN FALLS COUNTY, IDAHO

August, 1981

by

Robert E. Blackett

Earth Science Laboratory Division

University of Utah Research Institute

Work funded under Department of Energy/Division of
Geothermal Energy contract number DE/AC07/80ID12079

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

INTRODUCTION

The Earth Science Laboratory Division of the University of Utah Research Institute was requested by Fishbreeders of Idaho, Inc. to provide geologic assistance in locating a thermal water well for expansion of fishbreeding operations. This report summarizes the results of an on-site visit, geologic literature review, and compilation of existing water well data. The work was sponsored by the U.S. Department of Energy/Division of Geothermal Energy as part of DOE/DGE's User Assistance Program.

Fishbreeders of Idaho, Inc. are the operators of Idaho's largest single direct-heat application of geothermal water. This operation uses approximately 788 billion BTUs annually (Mitre Corp., 1980, p. 16) in raising several varieties of warm water fish species for commercial purposes.

The study area is located near Banbury Hot Springs in the Hagerman Valley along the west bank of the Snake River approximately 20 miles (32 km) west from the town of Twin Falls in south-central Idaho. The nearest community is the town of Buhl, Idaho, situated roughly four miles southeast (Figure 1).

Geothermal water from wells and springs is used for swimming pools, therapeutic baths, and commercial fish breeding at the site. The valley is the site for much of Idaho's commercial fish industry. Cold water fish species are raised from numerous cold springs that discharge from the canyon wall on the northeast side of the Snake River. Warm water fish species are raised in thermal water produced from wells located southwest of the Snake River. No thermal wells or springs are known to occur on the northeast side of the Snake River and therefore the general course of the river has been considered as the approximate boundary to the geothermal system (Lewis and Young, 1980, p.30).

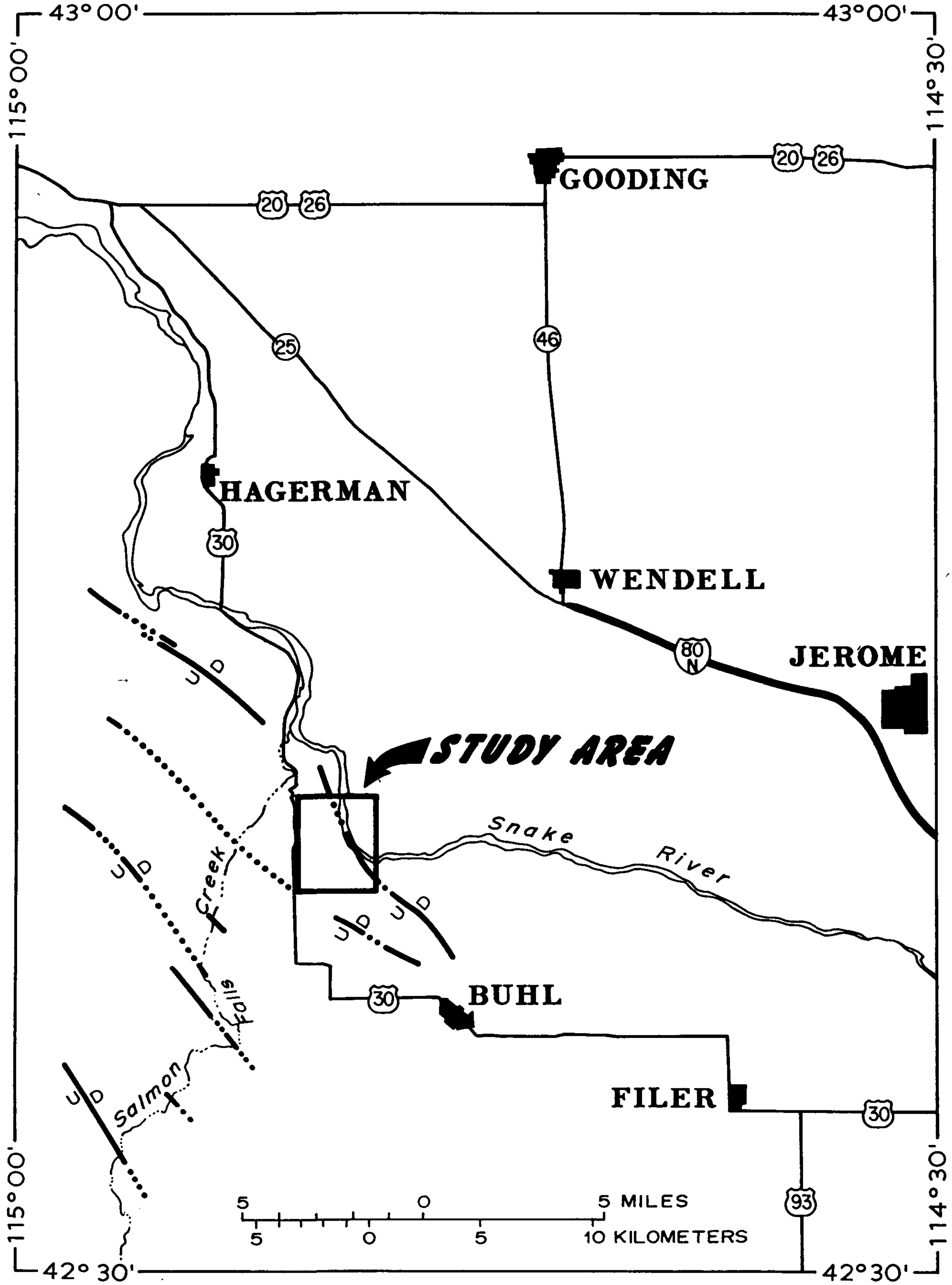

FIGURE 1: INDEX MAP SHOWING LOCATION OF FAULTS (AFTER MALDE, POWERS AND MARSHALL, 1963)

GEOLOGY

Regional Setting

The Hagerman Valley is situated near the juncture of the western and eastern divisions of the Snake River Plain geologic province. Cenozoic volcanic rocks are deformed by high-angle faulting and broad folding into a northwest-trending structural basin referred to as the Snake River graben. The Snake River graben is bounded on the northeast and southwest by numerous high-angle normal faults and contains several thousand feet of Tertiary-Quaternary volcanic rocks interstratified with lacustrine and fluvial sediments (Malde and Powers, 1962).

The study area lies on the southwestern flank of the Snake River graben where several northwest-trending normal fault blocks have been downdropped in step-like fashion to the northeast (Figure 1).

Volcanic/Sedimentary Stratigraphy

Volcanic and sedimentary rocks exposed in the study area have been divided by Malde and Powers (1962) into four groups ranging in age from lower Pliocene to recent (Figure 2). The principal formations present in ascending order are the Idavada Volcanics of lower Pliocene age, an unidentified clastic sedimentary unit possibly equivalent to the Poison Creek Formation of lower to middle Pliocene age, the Banbury Basalt of middle Pliocene age, and local patches of various Pleistocene Snake River Group formations.

"Idavada Volcanics" is a name applied to a complex series of ash-flow tuffs and lava flows that have a combined thickness in excess of 3000 feet (915 m) locally and are reportedly 600 feet (183 m) thick in Salmon Falls

SYSTEM	SERIES		GROUPS AND FORMATIONS	
QUATERNARY	Recent		Snake River Group	Recent lava flows
QUATERNARY	Pleistocene	Upper	Snake River Group	Melon Gravel
QUATERNARY	Pleistocene	Upper	Snake River Group	Bancroft Springs Basalt
QUATERNARY	Pleistocene	Upper	Snake River Group	Sand Springs Basalt
QUATERNARY	Pleistocene	Upper	Snake River Group	Crowsnest Gravel
QUATERNARY	Pleistocene	Upper	Snake River Group	Thousand Springs Basalt
QUATERNARY	Pleistocene	Upper	Snake River Group	Sugar Bowl Gravel
QUATERNARY	Pleistocene	Upper	Snake River Group	Madson Basalt
QUATERNARY	Pleistocene	Middle	Idaho Group	Black Mesa Gravel
QUATERNARY	Pleistocene	Middle	Idaho Group	Bruneau Formation
QUATERNARY	Pleistocene	Lower	Idaho Group	Tuana Gravel
TERTIARY	Pliocene	Upper	Idaho Group	Glenns Ferry Formation
TERTIARY	Pliocene	Middle	Idaho Group	Chalk Hills Formation
TERTIARY	Pliocene	Middle	Idaho Group	Banbury Basalt
TERTIARY	Pliocene	Lower	Idaho Group	Poison Creek Formation
TERTIARY	Pliocene	Lower	(West)	Idavada Volcanics (East)
TERTIARY	Miocene	Upper and Middle		Undifferentiated rocks

FIGURE 2: GENERALIZED STRATIGRAPHY OF CENOZOIC ROCKS IN THE WESTERN SNAKE RIVER PLAIN. (MODIFIED AFTER MALDE AND POWERS, 1962)

Creek near the study area (Malde and Powers, 1972). The Idavada Volcanics are mainly silicic latite and, to a lesser extent, rhyolite that appear massive, dense, and reddish-brown to black in color.

An unnamed sedimentary unit has been noted on drillers' logs from several water wells. The unit appears to be a sequence of volcaniclastic sediments of fluvial and lacustrine origin ranging in grain size from claystone and siltstone to pebble conglomerate. The unit is possibly equivalent to the Poison Creek Formation as described by Malde and Powers (1962, p. 1202) that unconformably overlies the Idavada Volcanics. The range in thickness of the unit within the study area is from 300 feet to 450 feet (92 m to 137 m) in a southeast direction and is likely a reflection of paleo-topographic control on deposition.

The Banbury Basalt overlies the unnamed sediments and is comprised of lower, middle, and upper parts. The lower and upper parts consist of decomposed olivine basalt separated by fluvial sand and gravel of the middle part. The lower part of the Banbury Basalt is the only part present over the entire study area and varies in thickness from 150 to 200 feet (46 m to 61 m). It occurs as multiple amygdular and columnar lava flows with individual thicknesses of 15 to 30 feet (4.6 m to 9.2 m).

GEOTHERMAL RESOURCES

Previous Work

A study of the geothermal resources in the Banbury Hot Springs area was recently completed by Lewis and Young (1980). Their work represents the most thorough assessment of the geothermal system to date. From thermal, hydrologic, chemical and isotopic studies they indicate that thermal waters of the Banbury system are the result of deep circulation of fluids and mixing with cold, shallow ground water.

Other workers have included the thermal occurrences in the Hagerman Valley as part of regional and statewide evaluations of geothermal resources. Mitchell and others (1980) presented chemical and hydrologic data for the Banbury area in addition to regional geophysics. Ross (1971) published water chemistry of thermal springs and wells in the Thousand Springs area. Malde and Powers (1962) provided detailed stratigraphic relationships of Cenozoic rocks of the western Snake River Plain including the Hagerman Valley area and later (1972) did detailed geologic mapping of the Glenns Ferry-Hagerman area.

Resource Occurrence

Thermal water in the Banbury area is thought to result from deep circulation along fractures associated with a northwest trending fault. Heat flow and chemical geothermometry studies suggest that water may move upward from depths of at least 4400 feet where wallrock equilibration temperatures range from 70° to 100°C (158° to 212°F) and mix in varying proportions with cooler, local ground water in a complex network of interconnected fractures. Wells drilled in the vicinity of Salmon Falls Creek have produced water at temperatures up to 72° C (162° F) (Lewis and Young, 1980, p. 30).

Reservoir temperatures in the Banbury Hot Springs area were estimated by Lewis and Young from analyses of water samples collected from numerous thermal wells. Silica and Na-K-Ca geothermometers were applied to water analyses from two of the wells included in this study. The estimated aquifer temperatures based upon the geothermometers are listed below in Table 1.

Well Number (Lewis & Young)	9S-14E-4DCC1	9S-14E-4CDB1
Well Number (This Report)	LR-1	LR-3
Surface Temp. (°F,°C)	95,35	93,34
Silica-Quartz Conductive (°F,°C)	221,105	225,107
Na-K-Ca (°F,°C)	185,85	180,82
Silica-Chalcedony (°F,°C)	169,76	172,78

Table 1: Estimated aquifer temperatures based upon geothermometry (taken from Lewis and Young, 1980, p. 16)

Wells drilled in the study area typically produce slightly alkaline, sodium bicarbonate-type water at temperatures between 32° and 35°C (90° to 95°F) with flow rates ranging up to 3000 gpm (Lewis and Young, 1980, p. 13). Thermal water is produced under artesian conditions at depths generally from 500 to 800 feet (153 m to 244 m) in fractured silicic volcanic rocks. Wells are collared in the lower part of the Banbury Basalt, penetrate a sequence of fine-grained clastic sediments, and bottom in silicic Idavada Volcanics. A lithologic profile based upon drillers' descriptions from a typical water well is shown on Figure 3. Flow rates in certain existing wells reportedly respond to production from new wells by decreasing, indicating that communication exists between certain wells (Leo Ray, 1981, personal communication).

In general, the older Idavada Volcanics have undergone faulting and fracturing more often than the overlying younger formations, thereby affording better opportunity for deep circulation of meteoric water. Where water wells intersect intensely fractured (more permeable) Idavada Volcanic rocks, relatively high flow rates are obtained.

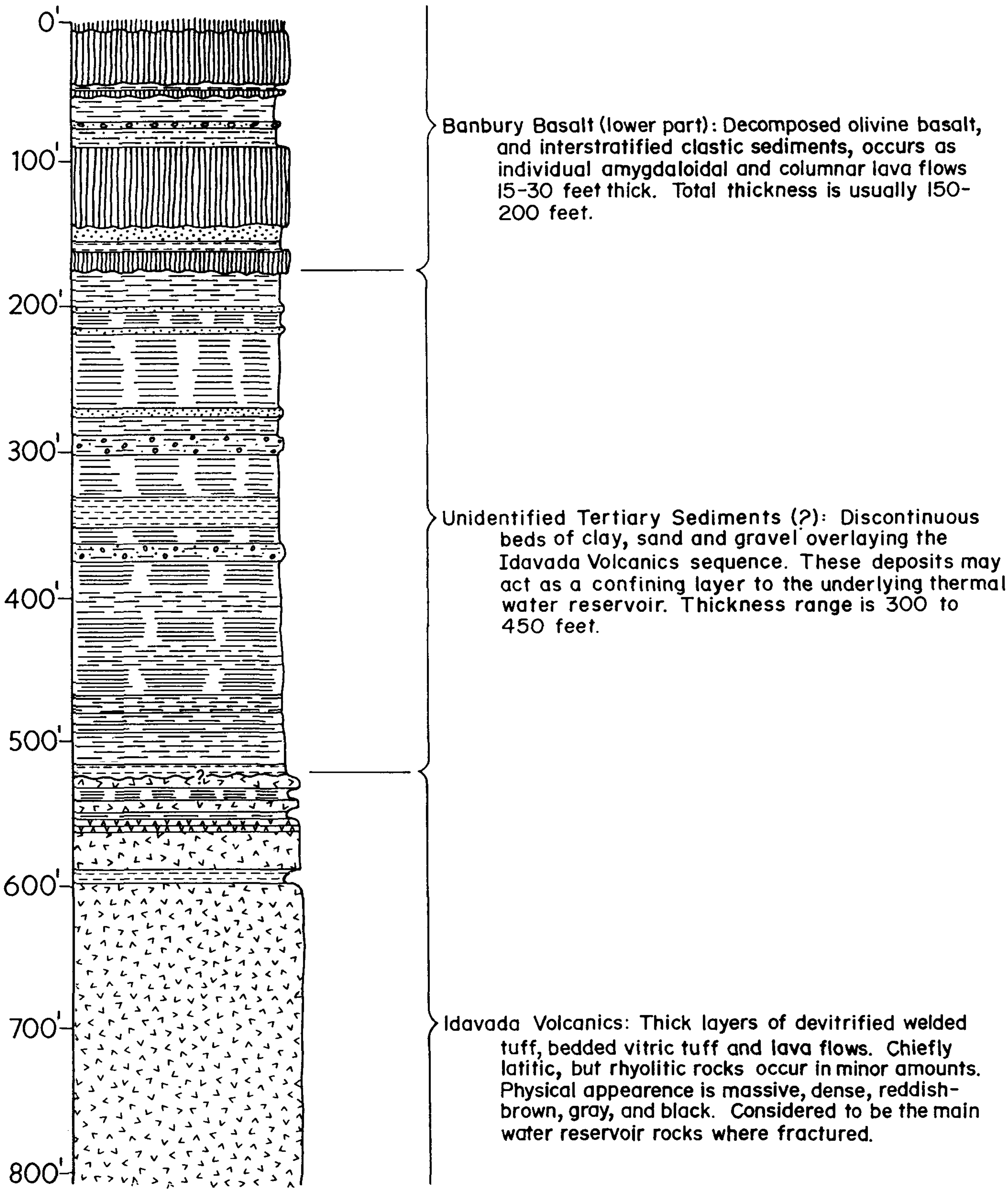

FIGURE 3: TYPICAL COLUMNAR SECTION RECONSTRUCTED FROM A DRILLER'S LOG IN THE STUDY AREA

The position of the fault trace as mapped by Malde and Powers (1972) becomes a factor in defining the location and extent of the geothermal system as fractures within the reservoir rock are thought to be associated with faulting. Lewis and Young (1980, p. 31) define a narrow elongate corridor coincident with the fault trace on Figure 4 as an area of both proven and potential geothermal resources.

Methodology

As part of this study, water well information was obtained from both the Idaho Department of Water Resources and Fishbreeders of Idaho, Inc. in an effort to better define subsurface geology and its relation to thermal water. Generalized columnar sections were constructed from drillers' logs to help determine formation contacts. A summary of the downhole information taken from drillers' logs is shown on Table 2. The lithologic descriptions were not made by a geologist and are therefore open to some question of accuracy. However, the descriptions are remarkably consistent and generally correlative from hole to hole.

From the water well data, the following geologic illustrations were produced: 1) a structure contour map drawn on the surface of the Idavada Volcanics (Plate 1); 2) an isopach map showing the thickness of Tertiary sediments overlying the Idavada Volcanics (Plate 2); and 3) structure - stratigraphic cross sections showing the relationship of rock units in the subsurface (Plate 3).

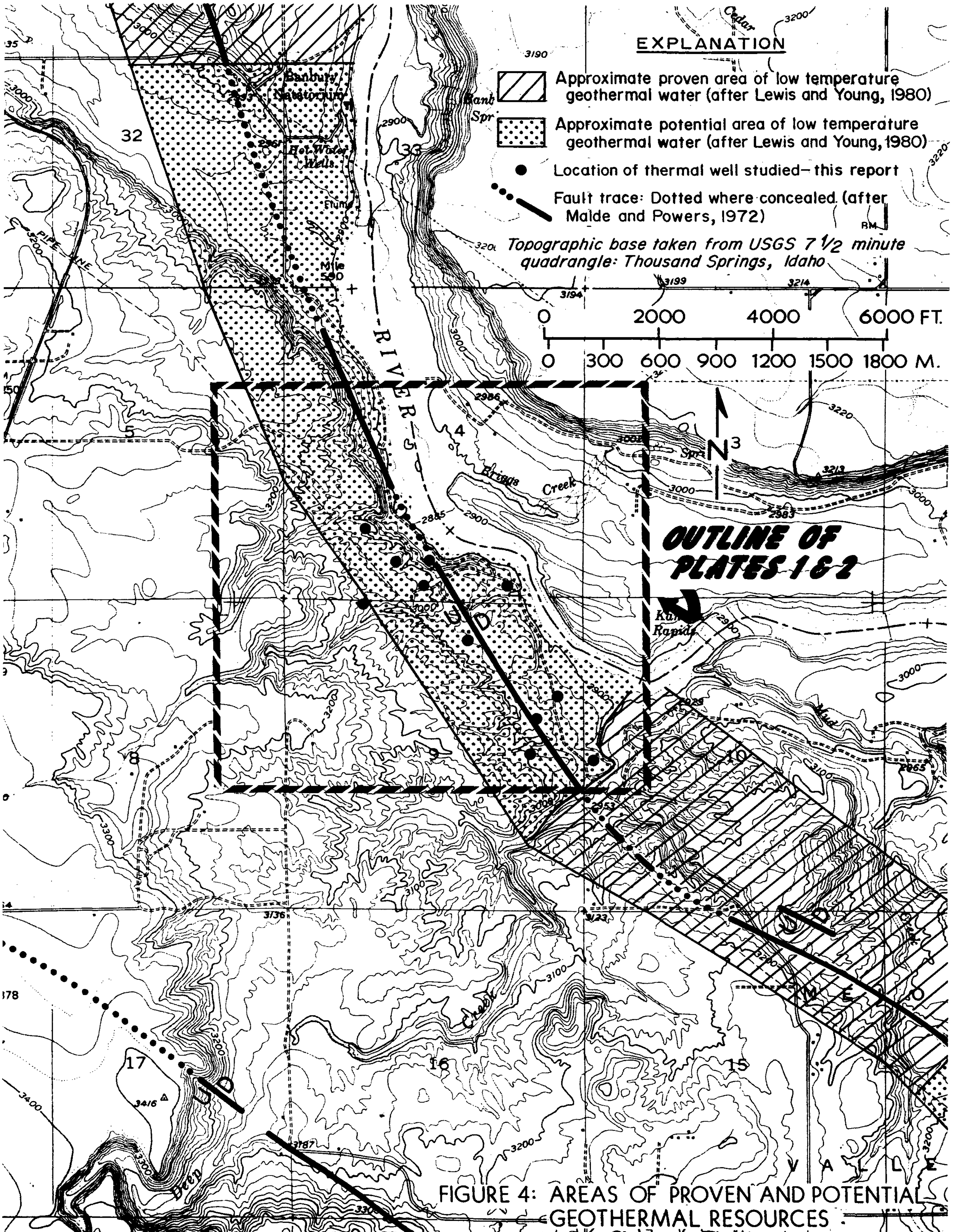

FIGURE 4: AREAS OF PROVEN AND POTENTIAL GEOTHERMAL RESOURCES

Table 2: Summary of Water Well Data

WELL NO.	TOTAL DEPTH ft (m)	LOCATION	COLLAR ELEV.* ft	COLLAR ELEV.* (m)	SUBSURFACE CONTACTS* FM top	Depth ft (m)	Elev ft (m)	FLOW RATE (gpm)	TEMP °F (°C)	REMARKS
KE-1	530 (162)	SE,NE,SEC.9,T.9S.,R.14E.	2970	(906)	Tbl	12 (3.7)	2958 (902)	600	86 (30)	Main Flow: 512'-530'
					Ts	190 (58)	2780 (848)			
					Tiv	605 (185)	2365 (721)			
KE-2	605 (185)	NW,SW,SEC.10,T.9S.,R.14E.	2955	(901)	Tbl	65 (20)	2890 (881)	1000	89 (32)	Main Flow: 535'-600'
					Ts	160 (49)	2795 (852)			
					Tiv	610 (186)	2345 (715)			
KE-3	750 (229)	SE,NE,SeC.9,T.9S.,R.14E.	2935	(895)	Tbl	0	2935 (895)	3000	88 (31)	Main Flow: 735'-750'
					Ts	145 (44)	2790 (851)			
					Tiv	595 (181)	2340 (714)			
L-1	850 (259)	SE,NE,SEC.9,T.9S.,R.14E.	2990	(912)	Tbl	5 (1.5)	2985 (910)	400	90 (32)	Main Flow: below 498'
					Ts	115 (35)	2875 (877)			
					Tiv	495 (151)	2495 (761)			
LR-1	590 (180)	SW,SE,SEC.4,T.9S,R.14E.	2910	(888)	Tbl	?	?	600	95 (35)	Well Data Question-able
					Ts	?	?			
					Tiv	?	?			
LR-2	755 (230)	SE,SW,SEC.4,T.9S,R.14E.	3010	(918)	Tbl	0	3010 (918)	1100	92 (33)	Main Flow: 665'-745'
					Ts	145 (44)	2865 (874)			
					Tiv	535 (163)	2475 (755)			
LR-3	610 (186)	SE,SW,SEC.4,T.9S.,R.14E.	3025	(923)	Tbl	20 (6.1)	3005 (917)	1500	93 (34)	Initial Production of 3000gpm was significantly decreased when well #LR-5 was completed. Main Flow: 505-560
					Ts	205 (63)	2820 (860)			
					Tiv	540 (165)	2485 (758)			
LR-4	675 (206)	NE,NW,SEC.9,T.9S.,R.14E.	3045	(929)	Tbl	25 (7.6)	3020 (921)	800	90 (32)	Main Flow: 567-578
					Ts	195 (59)	2840 (866)			
					Tiv	495 (151)	2550 (778)			
LR-5	750 (229)	SE,SW,SEc.4,T.9S.,R14E.	3025	(923)	Tbl	15 (4.6)	3010 (918)	2000	95 (35)	Main Flow: 536-750
					Ts	195 (59)	2830 (863)			
					Tiv	525 (160)	2500 (762)			
LR-6	1050 (320)	Sw,SE,SEC.4,T.9S.,R.14E	2925	(892)	Tbl	0	2925 (892)	300	90 (32)	Main Flow: 794-805
					Ts	170 (52)	2755 (840)			
					Tiv	520 (159)	2405 (733)			
LR-7	720 (220)	NW,NE,SEC.9,T.9S.,R.14E.	2980	(910)	Tbl	?	?	700	No Temp	Main Flow: 695-710
					Ts	135 (41)	2840 (866)			
					Tiv	500 (152)	2480 (756)			

* Estimated Values
Tbl: Lower Mbr. of Banbury Basalt; Ts: Unidentified Sedimentary Unit; Tiv: Idavada Volcanics

DISCUSSION

Some general observations can be made from the subsurface data. First, it is apparent that the thickness of Tertiary sediments shown on the isopach map (Plate 2) increases toward the downthrown (northeast) side of the fault, possibly a result of movement across the fault prior to or during deposition, or erosion after deposition. Secondly, dislocation along the fault may be of a scissor or rotational nature as suggested by the structure contour map (Plate 1), showing an attitude change between upthrown and downthrown blocks. Thirdly, thermal water production in all of the wells considered for this study was either confined within the Idavada Volcanics or in close proximity to the Idavada surface near the base of the Tertiary sediments.

An increased thickness of Tertiary sediments within the downthrown fault block likely is an indication of greater displacement and deformation within the Idavada Volcanics than within overlying rocks. Consequently, fracturing would likewise be more intense in the Idavada, thereby affording opportunity for greater permeability.

The significance of the scissor nature of faulting is probably not important on a local scale but may have regional applications in geothermal exploration. A regional study of the structure in lower Pliocene and older rocks may reveal sites of greatest fault displacements and intersections of two or more faults where thermal fluids are most likely to occur.

Artesian conditions are created by the thick, pliable, clay-rich Tertiary sediments that act as a confining layer to thermal water moving through the brittle, fractured Idavada Volcanics. Faults penetrating the Tertiary sediments may tend to be of a sealing nature whereby vertical fluid movement would be inhibited (Smith, 1980).

CONCLUSIONS AND RECOMMMENDATIONS

The fracture system controlling the movement of thermal fluids in the Idavada Volcanics, although thought to be related to a fault, is not well understood. The sedimentary and volcanic strata that overlie the reservoir rocks of the Idavada Volcanics have undergone less Cenozoic deformation and therefore tend to mask the underlying structure.

A production well should be sited and designed in order to take advantage of two circumstances surrounding the resource occurrence. The limits of the geothermal system have not been defined, but thermal water is known to occur along a narrow corridor coincident with the fault mapped on Plates 1, 2 and 3. Thermal water is mainly confined within or near the upper surface of the Idavada Volcanics. Together these conditions define a field and a minimum depth for a production well.

It is recommended that a production well be sited within the patterned area shown on Plate 1. The proposed well should be positioned so as to minimize interference with existing wells and drilled deep enough to test the upper portion of the Idavada Volcanics. It is recommended that the proposed well be drilled to a projected depth of at least 200 feet (61 m) below the top of the Idavada. The projected well depth at any point in the field can be determined from Plate 1 by subtracting the structural elevation of the Idavada surface from the topographic elevation (values in feet). The difference plus 200 will yield the projected well depth in feet.

REFERENCES

Lewis, R. E., and Young, H. W., 1980, Geothermal resources in the Banbury Hot Springs Area, Twin Falls County, Idaho: U.S. Geological Survey Water Resources Investigation Open-File Report 80-563, 34 p.

Malde, H. E., and Powers, H. A., 1962, Upper Cenozoic stratigraphy of western Snake River Plain, Idaho: Geological Society of America Bulletin, v. 73, p. 1197-1220.

Malde, H. E., and Powers, H. A., 1972, Geologic map of the Glenns Ferry-Hagerman Area, west-central Snake River Plain, Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-696.

Malde, H. E., Powers, H. A., and Marshall, C. H., 1963, Reconnaissance geologic map of west-central Snake River Plain, Idaho: U. S. Geological Survey Miscellaneous Geologic Investigations Map I-373.

Mitchell, J. C., Johnson, L. L., and Anderson, J. E., 1980, Geothermal investigations in Idaho: Idaho Department of Water Resources, Water Information Bulletin #30, part 9, 396 p.

Mitre Corporation, 1980, Geothermal progress monitor report number 4: U.S. Department of Energy Report DOE/RA-0051/4, 112 p.

Ross, S. H., 1971, Geothermal potential of Idaho: Idaho Bureau of Mines and Geology Pamphlet No. 150, 72 p.

Smith, D. A., 1980, Sealing and nonsealing faults in Louisiana Gulf Coast Salt Basin: American Association of Petroleum Geologists Bulletin, v. 64/2, p. 145-172.

Warner, M. M., 1975, Special aspects of Cenozoic history of Southern Idaho and their geothermal implications: Eng. Geol. Soils Eng. Symp., Proc., no. 13, p. 247-270.