DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN-FILE REPORT

DEEP DRILLING DATA, RAFT RIVER GEOTHERMAL AREA, IDAHO
RAFT RIVER GEOTHERMAL EXPLORATION WELL 4

T. 15 S., R. 26 E., sec. 23cd, Elev. 4843'

Compiled by H.R. Covington

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DISCUSSION

The southern Raft River Valley near Bridge, Idaho was designated the Frazier Known Geothermal Resource Area (Frazier KGRA) in 1971 by the U.S. Geological Survey (Godwin and others, 1971), based on two shallow wells, locally known as the Bridge and Crank wells, that flow boiling water. A geochemical and geological reconnaissance of selected thermal waters in Idaho was made by the U.S. Geological Survey (USGS) in 1972 (Young and Mitchell, 1973). Geochemical thermometry of water from the Bridge and Crank wells indicated a reservoir temperature of about 300°F (150°C).

The occurrence of boiling water in the Raft River Valley prompted the Raft River Rural Electric Cooperative, in 1971, to begin preliminary geological investigations applicable to the development of a geothermal electric generation facility in the valley. In 1973 the U.S. Energy Research and Development Administration (ERDA), as a result of proposals by the Raft River Rural Electric Cooperative, became interested in the Raft River Valley as a potential site for an experimental binary-fluid geothermal power plant.

In response to Senate Subcommittee Hearings in Idaho Falls, Idaho, on Geothermal Power in the Northwest, during August of 1973, the USGS, in cooperation with ERDA, began an integrated geological, geophysical, geochemical, and hydrological exploration program in southern Idaho. This program, underway by September 1973, was designed to provide a scientific framework for the evaluation of a geothermal resource and to test the applicability of various geological, geophysical, geochemical, and hydrological techniques to the study of geothermal resources. Williams and others (1976) summarize the early results of this program. In order to obtain the physical data necessary to evaluate these various techniques, a drilling program was instituted.

Initial shallow drilling was begun by the USGS, in cooperation with ERDA, in the spring of 1974, to measure the temperatures and flows of the near surface cold water aquifers. A total of thirty-four auger holes were drilled to depths of about 100 ft (30 m) (Crosthwaite, 1974), and a 323 ft (98 m) deep offset to the Bridge hot well was completed. In August of 1974, the USGS began drilling five core holes (Crosthwaite, 1976), in cooperation with the Idaho Department of Water Administration, to depths ranging from 250 ft (76 m) to 1,423 ft (434 m). The purpose of the core drilling was to test geophysical interpretations of the subsurface geology and to provide hydrological, geological, and geochemical data on the shallow part of the geothermal system.

The first Raft River Geothermal Exploratory borehole (RRGE #1) site was chosen so that deep drilling would intersect the Bridge fault at or near the base of the Salt Lake Formation (Miocene and Pliocene) and initially confirm the existence of hot water in quantities suitable for commercial power applications. Drilling of RRGE #1 began on January 5, 1975. On February 1, spontaneous flow began during routine geophysical logging at 4,632 ft (1,412 m); within 12 hours the well was producing approximately 1,800 gal/min (56 L/sec) artesian flow. Production casing was installed to 3,720 ft (1,134 m) and drilling continued to a total depth of 4,989 ft (1,521 m) in order to obtain geologic information on the Precambrian basement complex below the valley fill. The well was completed on April 1, 1975, and produces approximately 600 gal/min (28 L/sec) artesian flow with a bottom hole temperature of 295°F (146°C). The lithologic and geophysical logs of RRGE #1 are now available as USGS Open-File Report 77-226.

The second Raft River Geothermal Exploratory borehole (RRGE #2) site was chosen so that drilling would intersect the Bridge fault within the basement complex; allowing an accurate determination of the role the Bridge fault plays in the geothermal system. Drilling of RRGE #2 began on April 26, 1975 and continued to 4,227 ft (1,288 m), where cuttings and bottom hole temperature brought about the decision to install production casing. After the production casing was installed, drilling continued until a silica caprock was penetrated at 4,340 ft (1,323 m), and the well began to flow at approximately 400 gal/min (25 L/sec). A core was taken in the reservoir rock, and then drilling continued through the production zone and into the Precambrian basement rock to a total depth of 5,988 ft (1,825 m). As a result of flow testing, and examination of geophysical logs and cuttings during the summer of 1975, it was decided that the Bridge fault had not been intersected, and that the well should be deepened. Drilling resumed on March 4, 1976 with a new total depth of 6,543 ft (1,994 m) being reached on March 11, 1976. Geophysical logging, flow testing, and cuttings indicate no major active or open fault zone was crossed. The lithologic and geophysical logs of RRGE #2 are now available as USGS Open-File Report 77-243.

The third Raft River Geothermal Exploratory borehole (RRGE #3) site was chosen in order to determine the extent and capacity of the geothermal reservoir. Drilling began on March 28, 1976 and continued to 4,318 ft (1,316 m) where the first sidetrack began. Sidetrack-A was drilled in a westerly direction with an average deviation angle of 8°, through the remaining Tertiary basin fill and into the Precambrian basement to a depth of 5,853 ft (1,784 m). A flow test was conducted and geophysical logs run in sidetrack-A. The sidetrack produced approximately 40 gal/min (2.5 L/sec) artesian flow. Sidetrack-B was then drilled in a northeasterly direction from 4,530 ft (1,463 m) to 5,532 ft (1,686 m) with an average deviation angle of 7° 45'. No geophysical logging or flow testing was conducted on sidetrack-B. Sidetrack-C was drilled in a northerly direction with a continuously increased deviation angle from 1° 45' at the kickoff depth of 4,384 ft (1,336 m) to 22° 45' at the total depth of 5,917 ft (1,803 m). After flow testing with airlift stimulation, RRGE #3 began producing approximately 350 gal/min (22 L/sec) artesian flow with a bottom hole temperature of 295° F (146° C). The lithologic and geophysical logs of RRGE #3 are now available as USGS Open-File Reports 77-616 and 77-883.

The fourth Raft River Geothermal Exploratory borehole (RRGE #4) site was chosen in order to test the effects of large volume injection of geothermal fluids at intermediate depths (2,000-3,000 ft, 600-1,000 m) within the geothermal resource area. In the event that injection of geothermal fluids at this depth has adverse effects on the geothermal resource or the cold water aquifer above, the well is so sited that it could be deepened and used as a production well.

Drilling of RRGE #4 by Colorado Well Service, began on April 8, 1977. Drilling mud was used as the drilling fluid to 1,909 ft (582 m), with a core taken from 1,894 ft (577 m) to 1,909 ft (582 m). After the 13 3/8-inch (34 cm) surface casing was installed to 1,894 ft (577 m) drilling continued using water as the drilling fluid. A core was taken from 2,820 ft (860 m) to 2,840 ft (866 m) and as a result of high temperatures (200° F, 93° C) and permeable zones it was decided to discontinue drilling at this depth.

DATA SUMMARY

Drilling period:	April 8 -- May 4, 1977	
Total depth:	2,840 ft	866 m
Artesian flow:	250 gal/min	16 L/sec
Max. Temp.:	252° F	122° C
Surface casing:	1,894 ft	577 m

TOP OF FORMATION

Quaternary--Raft	26 ft	8 m
Tertiary--Salt Lake	365 ft	111 m

CORE

Core #1 1,894-1,909 ft (577-582 m) Tertiary--Salt Lake Formation: Sandstone; gray green, calcareous, tuffaceous, medium to coarse grained. Clasts of subangular to rounded quartz, feldspar, schist, and tuff

Core #2 2,820-2,840 ft (860-866 m) Tertiary--Salt Lake Formation: Sandstone; gray green, medium grained, with thin interbeds of tan, calcareous siltstone. Sand; medium grained, clean, angular to subrounded clasts of quartz, feldspar, schist, and biotite. Pyrite crystals scattered throughout. Silt, calcareous, micaceous, with scattered angular quartz and feldspar grains

GEOPHYSICAL LOGS

Log	Date	Run	Logged Interval Feet	Logged Interval Meters
Caliper	4-6-77	one	400-1,908	122-582
Compensated Densilog	4-6-77	one	400-1,908	122-582
Gamma	4-17-77	one	401-1,908	122-582
Compensated Neutron	4-17-77	one	401-1,908	122-582
BHC Acoustilog	4-16-77	one	401-1,901	122-579
Dual Induction Focused Log	4-15-77	one	403-1,886	123-575

EXPLANATION

Quaternary--Raft Formation: Massive beds of light-colored clay and silt and thin-bedded calcareous quartzose silt and sand that is cross-bedded locally. Conglomerate or gravel occurs at the base of the formation in many places (Trimble and Carr, 1976). The Raft Formation in the Raft River basin is primarily gravel containing clasts of Tertiary volcanic rock, Paleozoic limestone, and Precambrian quartzite derived from the surrounding mountains. These gravels are interbedded with light-colored calcareous silts and sands. The Raft Formation-Salt Lake Formation contact in the well is an arbitrary contact based on downward decrease in overall gravel content.

Tertiary--Salt Lake Formation: Gray to light-green thin-bedded to massive, tuffaceous siltstone and sandstone with minor beds of conglomerate. In the western part of the Raft River basin the Salt Lake Formation is divided by a volcanic member at Jim Sage Mountain into upper and lower members (Williams and others, 1976)

Upper member (Tsu) is gray to light-green tuffaceous siltstone and sandstone, and minor buff to gray conglomerate

Volcanic member at Jim Sage Mountain (Tsj) consists of rhyolite flows separated in many places by a vitrophyre breccia. The flows are black glassy and red-brown porphyritic-aphanitic calc-alkali rhyolite containing phenocrysts of oligoclase-andesine and pigeonite. The vitrophyre breccia consists of black glass clasts a few cm to 2 m in diameter in a yellow and orange matrix of hydrated glass (Williams, and others, 1976)

Lower member (Tsl) is gray and white thin-bedded to massive tuffaceous sandstone with light-green interbeds of claystone and siltstone and minor conglomerate

Formational contacts and lithologic changes within the Raft and Salt Lake Formations are based solely on the well cuttings and may not correspond exactly to changes in the geophysical logs. Cuttings and core were examined and described in the office and lithologic breaks assigned without the use of geophysical logs. Geophysical logging was carried out by Dresser Atlas Wireline Services. As a result of casing problems and the possibility of losing the logging tools the well was not logged below 1,909 ft (582 m). All depths, if not otherwise indicated, are measured depth from ground level.

REFERENCES

Covington, H. R., 1977a, Deep Drilling Data, Raft River geothermal area, Idaho, Raft River Geothermal Exploration Well #1: U.S. Geol. Survey Open-File Rept. 77-226.

_____1977b, Deep Drilling Data, Raft River geothermal area, Idaho, Raft River Geothermal Exploration Well #2: U.S. Geol. Survey Open-File Rept. 77-243.

_____1977c, Deep Drilling Data, Raft River geothermal area, Idaho, Raft River Geothermal Exploration Well #3: U.S. Geol. Survey Open-File Rept. 77-616.

_____1977d, Deep Drilling Data, Raft River geothermal area, Idaho, Raft River Geothermal Exploration Well #3 Sidetrack-C: U.S. Geol. Survey Open-File Rept. 77-883.

Crosthwaite, E. G., 1974, Preliminary data for thirty-four test wells augered in the Raft River Valley, February 13-March 8, 1974: U.S. Geol. Survey Open-file report, 17 p.

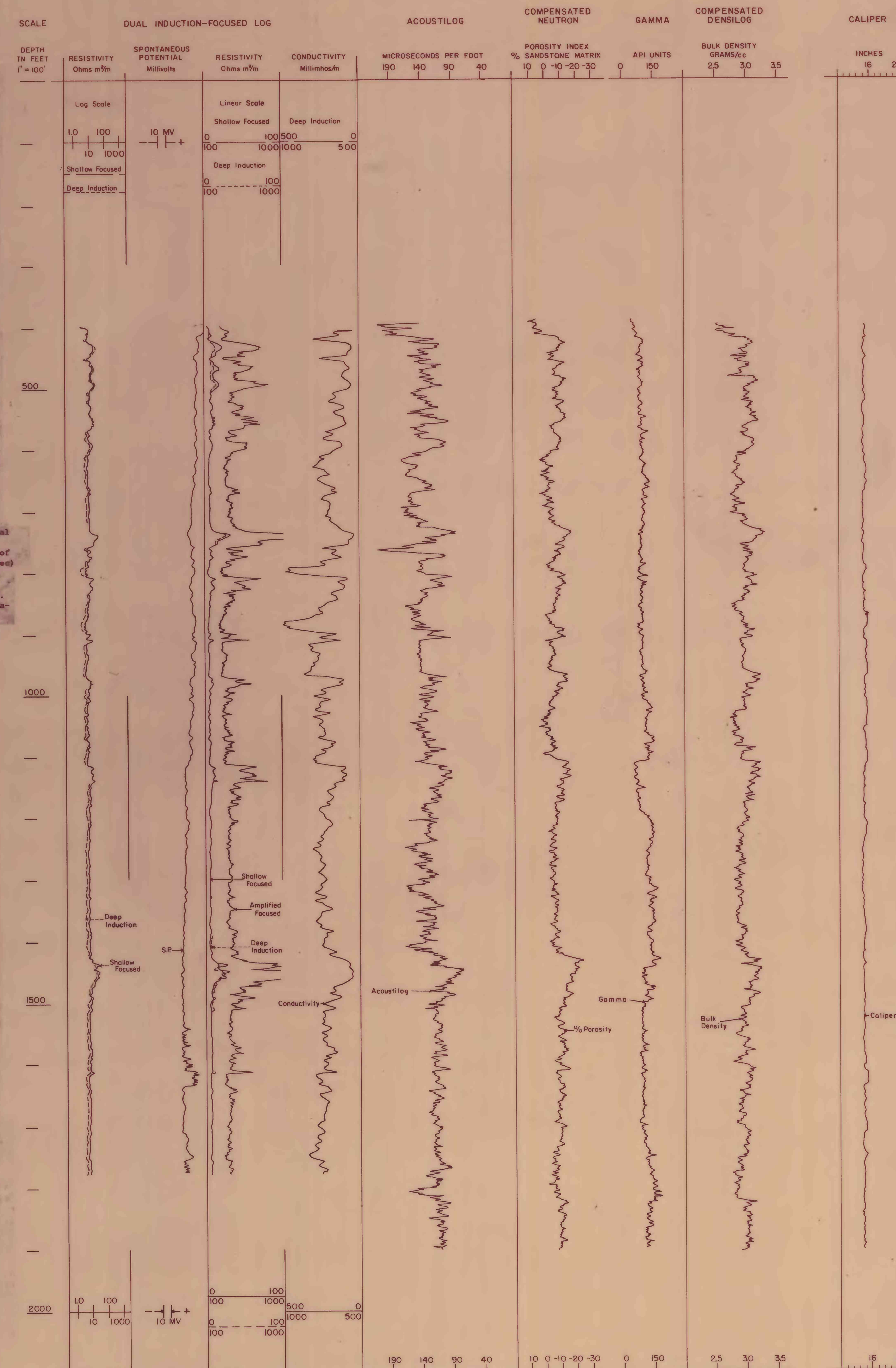
_____1976, Basic data from five core holes in the Raft River geothermal area, Cassia County, Idaho: U.S. Geol. Survey Open-File Rept. 76-665, 12 p.

Godwin, L. H., Haigler, L. B., Rioux, R. L., White, D. E., Muffler, L. J. P., and Wayland, R. G., 1971, Classification of public lands valuable for geothermal steam and associated geothermal resources: U.S. Geol. Survey Circ. 647, 17 p.

Trimble, D. E., and Carr, W. J., 1976, Geology of the Rockland and Arbon quadrangles, Power County, Idaho: U.S. Geol. Survey Bull. 1399, 115 p.

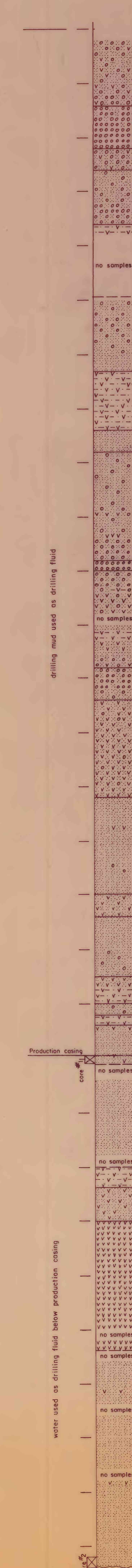
Williams, P. L., Mabey, D. R., Zohdy, A. A. R., Ackermann, H., Hoover, D. B., Pierce, K. L., and Oriel, S. S., 1976, Geology and geophysics of the southern Raft River Valley geothermal area, Idaho, U.S.A. [1976]: Second United Nations Symposium on the Development and Use of Geothermal Resources, San Francisco, Calif., May 20-29, 1975, v. 2, p. 1273-1282.

Young, H. W., and Mitchell, J. C., 1973, Geothermal investigations in Idaho--Part I, Geochemistry and geologic setting of selected geothermal waters: Idaho Dept. Water Admin. Water Info. Bull. 30, 43 p.



C° = 5/9(F° - 32°)   microsecond/m = microsecond/ft(0.3048)   cm = in(2.54)

LITHOLOGY



RAFT FORMATION

Sand and gravel: Sand is light greenish gray, fine to medium grained, quartzose, tuffaceous, and slightly calcareous. Gravel clasts of quartzite, dolomite, schist, volcanic member at Jim Sage Mountain (Tsj), and tuff range from 0.5-2 cm in diameter and are angular to subrounded

Gravel: Clasts of quartzite, dolomite, schist, Tsj, and tuff; clasts range from 0.5-2 cm in diameter and are angular to subrounded. Minor sand matrix is gray green, slightly calcareous, and quartzose

Sand and gravel: Sand is gray green, medium to coarse grained, quartzose, tuffaceous, and calcareous. Gravel clasts of quartzite, dolomite, schist, Tsj, and tuff are subangular to subrounded; 1-2 cm in diameter

Sand and gravel: Sand is coarse grained quartz, clear and angular to frosted and rounded. The sand appears to be unconsolidated and contains minor clasts of 1-2 cm, subrounded quartzite, dolomite, Tsj, and tuff

SALT LAKE FORMATION

Tuffaceous silt: Light green, slightly calcareous with minor clear, angular quartz grains

Sand and gravel: Sand is coarse grained and unconsolidated with clasts of quartz, feldspar and mica. Gravel clasts of quartzite, dolomite, schist, Tsj, and tuff are generally less than 1 cm in diameter and rounded

Tuffaceous silt: Gray to gray green in color and calcareous. Minor free grains of quartz and mica

Sand: Coarse, unconsolidated, angular to rounded clasts of quartz, feldspar, and Tsj. Trace of pyrite

Sand and gravel: Sand is coarse and unconsolidated clasts of quartz, feldspar, and Tsj. Gravel is generally less than 1 cm in diameter, angular to rounded clasts of quartzite, dolomite, schists, Tsj, and tuff. Trace of pyrite. Sand has tuffaceous lenses below 900 ft

Gravel: Unconsolidated, clasts angular to rounded, and 1-2 cm in diameter. 30 percent tuff, Tsj, quartzite, and trace of schist and pyrite

Tuffaceous sand and gravel: Sand is light green, calcareous, and tuffaceous with clasts of rounded quartz and feldspar. Gravel consists of 1-2 cm in diameter, rounded clasts of Tsj, and quartzite. Trace of muscovite

Gravel: Clasts of quartzite, dolomite, Tsj, tuff, and schist are 1-2 cm in diameter and rounded. Coarse sand matrix cemented with calcite. Trace of pyrite

Tuffaceous sand: Fine to medium grained, subangular to subrounded grains of quartz and tuff in a calcareous matrix. Scattered pebbles (1 cm) of quartzite and schist. Trace of pyrite, muscovite, chrome micas, and free calcite flakes

Sand: Coarse, unconsolidated and light green in color. Clasts of quartz, dolomite, tuff, and Tsj are angular to well rounded. Trace of muscovite, pyrite, and free calcite plates

Tuffaceous sand: Fine to medium grained clasts of subangular to subrounded quartz, feldspar, and tuff in a calcareous matrix

Sand: Medium to coarse grained, weakly cemented with calcite. Clasts of quartz, and feldspar. Trace of muscovite, biotite, and free calcite flakes

Tuffaceous silt and sand: Calcareous, sand is mainly quartz, abundant muscovite and calcite flakes. Overall sample color is greenish gray

Sand and gravel: Unconsolidated, coarse sand with subangular to subrounded clasts of quartz and feldspar, biotite and muscovite flakes. Gravel clasts are 1-2 cm in diameter, rounded, and consists of quartzite, Tsj and tuff

Tuffaceous silt: Light green, slightly calcareous, few free grains of angular, clear quartz

Sand: Fine to medium grained, clear to frosted, angular to rounded clasts of quartz and feldspar. Few thin tuffaceous calcareous interbeds

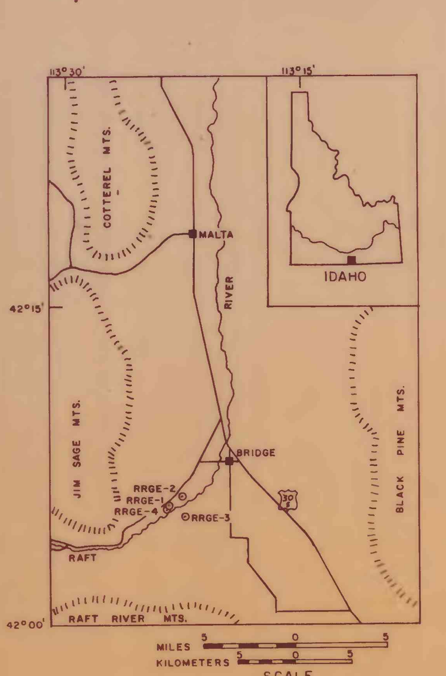
Sand: Coarse, unconsolidated clasts of subangular to subrounded quartz feldspar, schist, dolomite, tuff and Tsj

Tuffaceous siltstone: Light green, calcareous

Tuffaceous sand: Clasts of quartz and tuff with calcareous matrix, light green color

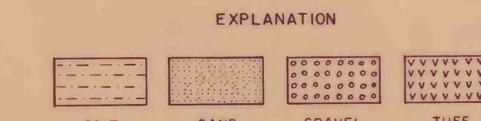
Tuff: Silty to sandy, light green in color, few free grains of quartz and muscovite. Noncalcareous. Trace of pyrite

Sand: Fine to medium grained with few thin interbeds of tuffaceous sand. Clasts are angular to subrounded, and clear to frosted. Abundant biotite and muscovite. Trace of pyrite. Overall sample color greenish gray



INDEX MAP

EXPLANATION



WELL-NUMBERING SYSTEM

Idaho well numbers indicate the locations of wells within the official rectangular subdivisions of the public lands, with reference to the Boise baseline and meridian. The first two segments of a number designate the Township and Range (T. 15 S., R. 26 E.). The third segment is the section number, followed by two letters which indicate the quarter-section, and the 40-acre tract (sec. 23cd). Quarter sections are lettered a, b, c, and d in counter-clockwise order from the northeast quarter. The 40-acre tracts are lettered in the same manner.