DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN-FILE REPORT
77-616

DEEP DRILLING DATA, RAFT RIVER GEOTHERMAL AREA, IDAHO

RAFT RIVER GEOTHERMAL EXPLORATION WELL #3

T. 15 S., R. 26 E., sec. 25bd Elev. 4850'

Compiled by H. R. Covington

1977

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.

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. 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 1973.

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. 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 (Crosthwaite, 1974), and a 323-ft-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 to 1,423 ft. 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 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; within 12 hours the well was producing approximately 1,800 gal./min. artesian flow. Production casing was installed to 3,720 ft and drilling continued to a total depth of 4,989 ft 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. artesian flow with a bottom hole temperature of 295°F. The lithologic and geophysical logs of RRGE #1 are now available as USGS Open-File Report 77-226, (Covington, 1977a).

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, 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 "cap rock" was penetrated at 4,340 ft, and the well began to flow at approximately 400 gal./min. 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 5,998 ft. 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 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 (Covington, 1977b).

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 of RRGE #3 by Reynolds Electrical and Engineering Company, Inc., began on March 28, 1976, using drilling mud to 1,383 ft where 13 3/8-inch surface casing was installed. Drilling then continued, using water as drilling fluid, to 4,240 ft, taking cores at 2,786 ft, 3,347 ft, and 3,947 ft. The decision to install production casing at 4,240 ft was brought about by an increase in alteration of the cuttings and a bottom hold temperature of 249°F. After the 9 5/8-inch production casing was installed, drilling continued to 4,318 ft, where the first sidetrack began.

Sidetract-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. Geophysical logs were run in sidetrack-A and a flow test conducted. The sidetrack produced approximately 40 gal./min. artesian flow with a 285°F bottom hole temperature.

Sidetract-B, beginning at 4,530 ft, was drilled in a northeasterly direction, with an average drift angle of 7°45', to a depth of 5,532 ft. Total production from the well then increased to approximately 100 gal./min., with a bottom hole temperature of 295°F.

Sidetrack-C was then drilled from 4,384 ft, in a northerly direction, to a total depth of 5,917 ft. The drift angle in this sidetrack was continuously increased from 1°45' at the kickoff point to 22°45' at total depth. Cores were taken in the Tertiary basin fill at 4,958 ft, and 5,249 ft; and in the Elba Quartzite at 5,532 ft. Just below the kickoff point, very clean cuttings of schist and quartzite were recovered, with a good break above, below, and between the two "units." At present this is attributed to contamination by cuttings from sidetracks A and B. After flow testing with airlift stimulation, this sidetrack brought total production of the well to approximately 350 gal./min. artesian flow with a bottom hole temperature of 295°F. Flow testing of RRGE #3 does indicate that all three wells (RRGE #1, RRGE #2, and RRGE #3) are in the same reservoir and that the reservoir is very large.

GENERAL DATA SUMMARY

Drilling period:	March 28-May 24, 1976
Total depth:	5,917 ft.
Production zone:	4,400-5,400 ft.
Production casing:	4,240 ft.
Artesian flow:	350 gal./min.
Max. Temp.:	295°F

SIDETRACK-A DATA SUMMARY

Drilling period:	April 24-May 1, 1976
Average drift angle:	8°
General drift direction:	West
Artesian flow:	40 gal./min.
Maximum temperature:	285°F

	meas. depth	vert. depth	angle	direct.
Kickoff point:	4,318 ft.	4,313 ft.	5°45'	N 87° W
Total depth:	5,853 ft.	5,831 ft.	6°45'	N 65° W

Formation	meas. depth	vert. depth
Precambrian-Quartzite of Yost	5,240 ft.	5,224 ft.
Precambrian-Schist of the Upper Narrows	5,400 ft.	5,382 ft.
Precambrian-Elba Quartzite	5,485 ft.	5,466 ft.
Precambrian-Older Schist	5,720 ft.	5,700 ft.
Precambrian-Quartz Monzonite	5,835 ft.	5,814 ft.

SIDETRACK-B DATA SUMMARY

Drilling period:	May 7-May 14, 1976
Average drift angle:	7°45'
General drift direction:	Northeast
Artesian flow:	60 gal./min.
Maximum Temperature:	295°F

	meas. depth	vert. depth	angle	direct.
Kickoff point:	4,530 ft.	4,522 ft.	8°45'	N 78° W
Total depth:	5,532 ft.	5,512 ft.	14°	N 31° E

Formation	meas. depth	vert. depth
Precambrian-Quartzite of Yost	5,340 ft.	5,326 ft.
Precambrian-Schist of the Upper Narrows	5,412 ft.	5,396 ft.
Precambrian-Elba Quartzite	5,510 ft.	5,492 ft.

SIDETRACK-C DATA SUMMARY

Drilling period:	May 16-May 24, 1976
Average drift angle:	13°
General drift direction:	Northwest
Artesian flow:	250 gal./min.
Maximum Temperature:	295°F

	meas. depth	vert. depth	angle	direct.
Kickoff point:	4,384 ft.	4,378 ft.	1°45'	N 85° W
Total depth:	5,917 ft.	5,844 ft.	22°45'	N 60° W

Formation	meas. depth	vert. depth
Precambrian-Quartzite of Yost	5,342 ft.	5,306 ft.
Precambrian-Schist of the Upper Narrows	5,400 ft.	5,359 ft.
Precambrian-Elba Quartzite	5,502 ft.	5,456 ft.
Precambrian-Older Schist	5,715 ft.	5,656 ft.
Precambrian-Quartz Monzonite	5,795 ft.	5,731 ft.

CORE

Core #1 2,786-2,796 ft. Tertiary-Salt Lake Formation
Siltstone and sandstone: alternating light-gray sandstone, and dark-gray siltstone laminae; tuffaceous, calcareous, minor pyrite, and some soft-sediment deformation; 2,808 ft a 5-inch conglomerate layer with subrounded to well-rounded, 0.3-2-inch in diameter quartzite, quartz, and rhyolite clasts. Bedding dip 15°.

Core #2 3,347-3,364 ft. Tertiary-Salt Lake Formation
Sandstone: light green, tuffaceous, non-calcareous cement. Quartz sand; well rounded, frosted, fine to coarse grained. Many fractures with 60° dips, most containing gypsum, and analcite crystals.

Core #3 3,947-3,962 ft. Tertiary-Salt Lake Formation
Siltstone and sandstone: alternating thin laminae of dark-brown to gray siltstone, and light-gray sandstone; calcareous, tuffaceous, abundant muscovite, minor biotite, and trace of sulfides; occasional quartz pebbles; soft-sediment deformation throughout; bedding dip 60° at top of core, decreasing to 20° at bottom; many small fractures and faults, all high angle and generally dip opposite the bedding.

Core #4 4,958-4,978 ft. Tertiary-Salt Lake Formation
Siltstone and sandstone: alternating laminae of greenish-gray siltstone, and green sandstone; calcareous, tuffaceous; soft-sediment deformation throughout; bedding dips 30°-40°; many fractures dipping 60° to vertical; brecciated zone 4,978-4,981 ft.

Core #5 5,249-5,258 ft. Tertiary-Salt Lake Formation
Siltstone and sandstone: alternating thin laminae of brown siltstone, and light-green sandstone; calcareous, tuffaceous; bedding dip 25°; fractures vertical to 70° throughout, open or filled with calcite.

Core #6 5,532-5,533 ft. Precambrian-Elba Quartzite
Quartzite: white to milky, clean, dense, micas on bedding surfaces, and rare magnetite grains.

GEOPHYSICAL LOGS

Log	Date	Run	Logged Interval
Caliper	4-17-76	Two	1,385-4,209 ft.
Caliper	5-1-76	Three	4,247-5,856 ft.
Compensated Densilog	4-17-76	Two	1,384-4,209 ft.
Compensated Densilog	5-3-76	Three	4,247-5,863 ft.
Gamma	4-17-76	Two	1,384-4,209 ft.
Gamma	5-3-76	Three	4,247-5,863 ft.
Compensated Neutron	4-17-76	Two	1,385-4,208 ft.
Compensated Neutron	5-1-76	Three	4,200-5,863 ft.
BHC Acoustilog	4-18-76	Two	1,385-4,201 ft.
BHC Acoustilog	5-1-76	Three	4,247-5,856 ft.
Dual Induction Focused Log	4-17-76	Two	1,385-4,209 ft.
Dual Induction Focused Log	5-2-76	Three	4,247-5,863 ft.
Temperature	5-1-76	Three	Survace-5,868 ft.

EXPLANATION

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 at Jim Sage Mountain, the Salt Lake Formation is divided by a volcanic member 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 containing subrounded to well-rounded clasts of quartzite, dolomite, limestone, schist, and rhyolite.

Volcanic member at Jim Sage Mountain (Tsj) consists of rhyolite flows separated by light-gray and white tuffaceous siltstones and sandstone, and 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, 1974).

Lower member (Tsl) is gray and white thin-bedded to massive tuffaceous sandstone with light-green interbeds of claystone and siltstone, and minor conglomerate containing clasts of quartzite, dolomite, limestone, and schist.

Precambrian--Quartzite of Yost: White, sparsely to moderately muscovitic in beds a foot or less thick, green and greenish-gray coloration due to chromian mica can be found throughout. May contain as much as 10 percent K-feldspar (Compton, 1972).

Precambrian--Schist of the Upper Narrows: Dark-brown to gray, fine- to medium-grained biotite schist and fine-grained gneiss that contains quartz or quartz-feldspar lenses (Compton, 1972).

Precambrian--Elba Quartzite: White, tan or locally pale-green quartzite with muscovite-quartz schist between some beds (Compton, 1972).

Precambrian--Older Schist: Brown and silvery mica-rich schists consisting of muscovite-biotite-quartz schist, mica-plagioclase-microcline-quartz schist, and muscovite-quartz schist (Compton, 1972).

Precambrian--Quartz Monsonite: Gneissic, light to dark greenish-gray with a trace of pyrite and magnetite.

Formational contacts and lithologic changes within the Salt Lake Formation 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 at the well site by James W. Mytton and H. R. Covington during drilling, and lithologic breaks assigned without the benefit of geophysical logs. Sample depth control was maintained, through the use of a carbide lag, by Rocky Mountain Geo-Engineering Company; this unit was released at 5,600 ft in Sidetrack-C. Directional drilling surveys were carried out by Eastman Whipstock, Inc. Geophysical logging was carried out by Dresser Atlas Wireline Services.

Calibration of individual geophysical logs changes from run to run and has been adjusted to a single calibration for this publication. The Caliper log below 4,209 ft is from the BHC Acoustilog. Interruptions in the geophysical log data indicate depth intervals for which there is no commercially run geophysical logs or no geophysical logs provided. No geophysical logs were run in Sidetrack-B; it is expected that logging of Sidetrack-C will be carried out in the near future.

All depths, if not otherwise indicated, are measured depth from ground level.

REFERENCES

Compton, R. R., 1972, Geologic map of the Yost quadrangle, Box Elder County, Utah, and Cassia County, Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I-672.

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.

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.

Williams, P. L., Pierce, K. L., McIntyre, D. H., and Schmidt, P. W., 1974, Preliminary geologic map of the southern Raft River Valley, Cassia County, Idaho: U.S. Geol. Survey open-file report.

Williams, P. L., Mabey, D. R., Zohdy, A. A. R., Ackerman, 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 1, Geochemistry and geologic setting of selected geothermal waters: Idaho Dept. Water Admin. Water Info. Bull. 30, 43 p.

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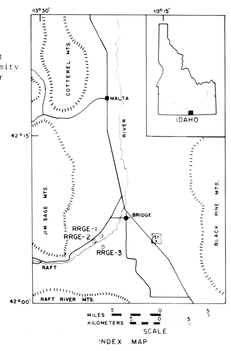
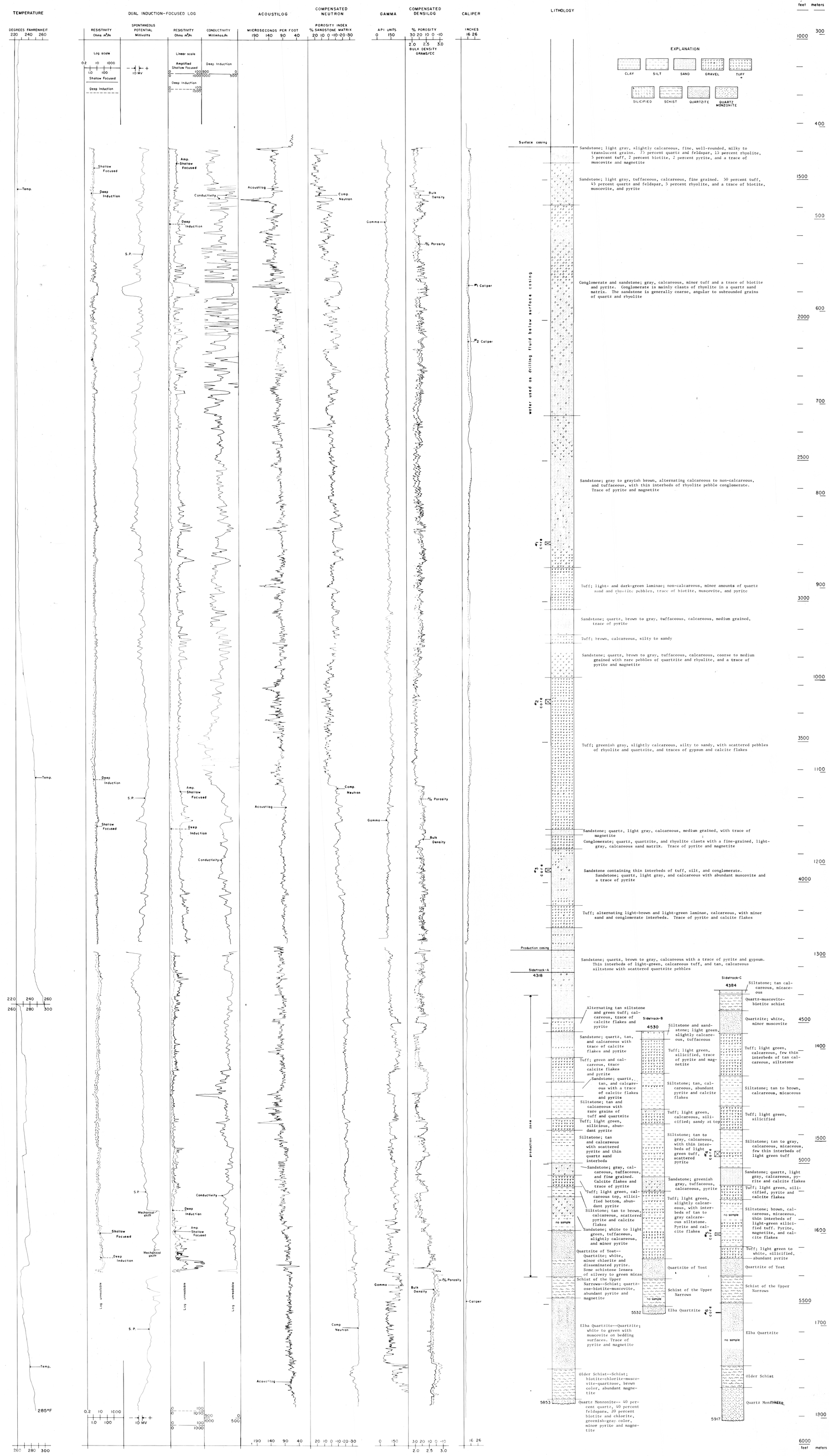
This map is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.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