THE RESULTS OF INTERMEDIATE DEPTH DRILLING
AT THE GLASS BUTTES PROSPECT
LAKE COUNTY, OREGON

by

WALTER R. BENOIT

JANUARY, 1981

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
PREVIOUS HISTORY	3
STRAT. TEST #1	3
FRANCANA GB-16	5
STRAT. TEST #2	6
STRAT. TEST #3	8
STRAT. TEST #4	8
UPDATED SHALLOW TEMPERATURE GRADIENT DATA	9
RE-INTERPRETATION OF THE SHALLOW THERMAL ANOMALY	10
ESTIMATED DEPTH TO 400°F	13
CONCLUSIONS.	16
RECOMMENDATIONS	17
BIBLIOGRAPHY	18
APPENDIX A	
APPENDIX B	

LIST OF FIGURES

	Page
Figure 1 Location Map	2

LIST OF TABLES

	Page
Table 1 Estimated Depth to 400°F	14

LIST OF PLATES

- Plate 1 Lithologic Log of Strat. Test #1
- Plate 2 Temperature Profiles from Strat. Test #1
- Plate 3 Temperature Profiles from Francana GB-16
- Plate 4 Lithologic Log of Strat. Test #2
- Plate 5 Temperature Profiles from Strat. Test #2
- Plate 6 Lithologic Log of Strat. Test #3
- Plate 7 Temperature Profiles from Strat. Test #3
- Plate 8 Lithologic Log of Strat. Test #4
- Plate 9 Temperature Profiles from Strat. Test #4
- Plate 10 Temperature Gradient Map
- Plate 11 200 Foot Isothermal Map
- Plate 12 Glass Buttes Strat. Tests Equilibrium Temperature Profiles
- Plate 13 Estimated Depth to 400°F

Introduction

During July and August of 1980 Phillips Petroleum Company drilled three intermediate depth temperature gradient holes (strat. tests) at Glass Buttes in Lake County, Oregon (Fig. 1). These holes are the culmination of three years of parttime negotiations with the Vulcan Group which controls most of what was believed to be the most promising geothermal acreage at Glass Buttes. The holes were drilled on Vulcan Group geothermal leases to earn half interest in one section per strat. test provided Phillips commits to drill a deep test well within the six months beginning November, 1980.

This report presents the results of this drilling and updates the thermal and geological interpretation of the Glass Buttes prospect.

It is concluded that there is probably no 400°F or hotter geothermal reservoir present in the immediate vicinity of Glass Buttes. It is recommended that Phillips not drill additional strat. tests or a test well at Glass Buttes. It is also recommended that Phillips Federal geothermal leases at Glass Buttes be dropped so that the acreage can be used in other Oregon prospects.

FIGURE 1

MAP OF OREGON SHOWING THE LOCATION OF THE AREA OF INTEREST.

ALSO INCLUDED ARE MAJOR STRUCTURAL FEATURES AND RHYOLITIC DOMES IN THE SOUTHEASTERN PART OF THE STATE. (BLACK AREAS) HACHURES ARE SHOWN ON THE DOWNTOWN SIDE OF THE LARGER FAULTS OF THE BASIN AND RANGE PROVINCE.

(FROM MACLEOD ET AL. 1975)

Previous History

In June, 1977 a fairly comprehensive report on the Glass Buttes area was completed (Benoit, 1977). This report contains much geological, geochemical, geophysical, and shallow temperature-gradient data covering an area of approximately 200 square miles. The temperature-gradient data showed a huge thermal anomaly to underlie the rhyolitic rocks exposed at Glass Buttes. Thermal gradients up to 12.9°F/100 feet are present. The geologic mapping showed several square miles of intense hydrothermal alteration containing mercury at the east end of the buttes. The geophysical and geochemical data are ambiguous and could not be properly evaluated without data from deeper drill holes. The geology and temperature data in the June, 1977 report justified the drilling of a 2000-foot strat. test which was drilled in late December, 1977 and early January, 1978 on Federal leases controlled by the Vulcan Group.

The temperature and geological data from Strat. Test #1 were encouraging so negotiations with the Vulcan Group, then known as California Geothermal, were begun. Negotiations with the Vulcan Group went slowly as the group apparently had little knowledge of geothermal exploration. After the Vulcan Group spent about \$100,000 on a strat. test (Francana GB-16) in the fall of 1979 with poor results the negotiations proceeded relatively rapidly. An agreement committing Phillips to drill up to five strat. tests by November, 1980 was signed in May, 1980. Drilling began in July, 1980.

Strat. Test #1

Strat. test #1 is located in SW $\frac{1}{4}$ NE $\frac{1}{4}$ Section 33, T23S-R23E. It was drilled between December 7, 1977 and January 6, 1978 to a depth of 2007 feet. Actual drilling time was only 14 days which was very good considering the cold and stormy weather. The drillers report for all the strat. tests is included as Appendix A in this report. Only minor lost circulation problems occurred, however, a small

amount of fluid was constantly lost during drilling.

Strat. test #1 is located about one-half mile southwest of the Ryan Well which prior to drilling strat. test #1 was the deepest and hottest hole in the area. Strat. test #1 is also located at the exposed western margin of the hydrothermally altered area. This drill hole is on Vulcan Group leaseholdings about 1.3 miles from the nearest acreage leased by Phillips. The location was picked because it was believed to offer the greatest chance of obtaining encouraging temperature data.

Plate 1 is a lithologic log of strat. test #1. The drill hole penetrated a 103-foot-thick basalt flow at a depth of 12 feet. Below the basalt a 45-foot-thick sequence of sand, clay, and gravel is present. Between 160 and 2000 feet glassy rhyolite flows and obsidian are present. All of this interval has been hydrothermally altered. The alteration varies from slightly perlitic obsidian to white opalite and clay. The cuttings from strat. test #1 can easily be interpreted to resemble the alteration exposed in the largest mining scar about one-half mile southeast of strat. test #1.

All available temperature profiles from strat. test #1 are shown on Plate 2. The first profile, run by Agnew and Sweet on January 7, 1978 was obtained one day after completion of the hole, before setting a retrievable plug, and clearly does not represent equilibrium conditions. Four weeks later, on February 4th, the hole was probed to a depth of 980 feet by the author with measurements at 20-foot intervals. This profile clearly shows a weak reversal at a depth of 820 feet and a second weaker reversal at 940 feet. These are probably the result of lost drilling fluid remaining near the wellbore. Circulation was lost at depths of 826 feet and 896 feet. The water level in the tubing was between 280 and 300 feet so no data was obtained above a depth of 300 feet. Immediately after the Phillips data was obtained Agnew and Sweet ran a second survey. This survey is assumed to represent equilibrium conditions below a depth of 300 feet, except for

the area near the reversals. On this Agnew and Sweet profile the first reversal is shown at a depth of 860 feet which is 40 feet lower than shown on the Phillips profile. The depth shown on the Phillips profile is correct. Depth control by Agnew and Sweet is poor. Between a depth of 1260 and 1880 feet the temperature gradient is a linear $6.6^{\circ}\text{F}/100$ feet. At 1880 feet the gradient decreases to $5.6^{\circ}\text{F}/100$ feet to the bottom of the tubing at 1984 feet. This decrease near the bottom of the hole introduces some uncertainty in extrapolating the temperature profile to greater depths.

Francana GB-16

Francana GB-16 is located in NE $\frac{1}{4}$ SW $\frac{1}{4}$ Section 19, T23S-R23E. Between August 31, and September 19, 1979 the hole was drilled to a depth of 2052 feet by Geothermal Services, Inc. for Francana Resources, Inc., a member of the Vulcan Group. A report on this hole has been prepared by Geothermal Services, Inc. for Francana and is available at Phillips' Reno office.

This hole was located by the Vulcan Group on Federal ground on which leases had been previously issued. It is near the center of the Vulcan Group lease applications. Discussions with Gene Ciancanelli indicate the hole was purposely drilled several miles from strat. test #1 in anticipation of a data trade. Lastly the hole is located near a previously drilled Oregon Department of Geology and Mineral Industry temperature-gradient hole which has a gradient of $8.1^{\circ}\text{F}/100$ feet to a depth of 200 feet.

A lithologic log has been prepared by Eugene V. Ciancanelli. A copy of this log is presented in this report as Appendix B. To a depth of 710 feet the cuttings consist of obsidian, rhyolite, and perlitic rhyolite with occasional iron staining. Below 710 feet no cuttings returned to the surface. A couple of bit samples were recovered which suggest the lithologies present to be ash-flow tuffs and sediments.

Two temperature profiles of Francana GB-16 are shown on Plate 3. The first profile is quite irregular between depths of 1720 feet and 1900 feet, presumably showing fractures recently filled with lost drilling fluid.

The latest available temperature profile was obtained on October 19th, one month after completion. This profile is difficult to interpret for two reasons. First it is complicated and secondly it is known that water was entering the wellbore and falling an unknown distance down the wellbore as it could be heard on the surface.

The temperature profile is a linear $3.3^{\circ}\text{F}/100$ feet to a depth of 340 feet. This is probably above the water table. Between 340 feet and 720 feet the temperature rapidly increases from 59°F to 122°F . This section of the profile cannot represent equilibrium conductive conditions. Convection of hot and/or cold water is required to explain this part of the profile. Between 720 feet and 1720 feet the profile is nearly isothermal with an average gradient of $0.5^{\circ}\text{F}/100$ feet. This interval can be explained by natural convection or by thermal water from an aquifer at 720 feet falling down the borehole to a depth of 1720 feet and exiting via fractures. Below 1720 feet the profile has a decreasing positive gradient. The decreasing nature of this part of the profile makes it difficult to extrapolate the temperature data with confidence to substantially greater depths. The average temperature gradient of the entire hole is $4.6^{\circ}\text{F}/100$ feet and the average heat flow is 2.3 HFU.

Strat. Test #2

Strat. Test #2 is located in SE $\frac{1}{4}$ SE $\frac{1}{4}$ Section 22, T23S-R23E. It was drilled between July 19 and 27, 1980 to a depth of 1220 feet. The hole was stopped at 1220 feet due to lost circulation problems. Tubing was originally set to a depth of 1060 feet by mistake and later deepened to 1180 feet.

The location, near the border between Phillips and Vulcan Group leases, was

picked to evaluate both groups' acreage and possibly earn one-half interest in one section of Vulcan's leases. The location is also in an area of high near-surface thermal gradients 1.9 miles northeast of strat. test #1.

A lithologic log of strat. test #2 is shown on Plate 4. Gravel and alluvium are present to a depth of 160 feet. Below 160 feet rhyolite and obsidian are present. Above 1000 feet the rhyolites are fresh. Between 1000 feet and 1090 feet some slight to moderate hydrothermal alteration has occurred. Below 1090 feet the rocks are intensely altered to opal and clay with some pink to red iron staining.

Temperature profiles from strat. test #2 are shown on Plate 5. All the profiles were obtained at least a week after the hole had been last disturbed. In spite of this precaution there is a rather wide spread in temperatures which is attributable to the use of three different probes and associated calibration differences, especially among the Pruett instruments. All the profiles are similar in shape except below 1080 feet.

During drilling severe lost circulation problems were encountered at 1180 feet and 1220 feet. Over 1250 barrels were lost in the hole during these drilling problems. The Phillips profile obtained on September 2, 1980 shows a small temperature reversal at 1110 feet. The Pruett temperature profiles obtained on October 9, 1980 and November 15, 1980 show no reversal. Therefore, it is believed the reversal is a transient feature caused by lost drilling fluid.

At 1080 feet the temperature gradient on the two latest Pruett profiles sharply decreases from 5.8°F/100 feet to 2.2°F/100 feet. It is not known if the lower gradient segment extends to great depths or is a perturbation on the higher gradient segment. In either case extrapolating the temperature data involves some ambiguity.

Strat Test #3

Strat. test #3 is located in NW $\frac{1}{4}$ SE $\frac{1}{4}$ Section 35, T23S-R23E. It was drilled between July 29 and August 11, 1980 to a depth of 840 feet. Severe lost circulation was the reasons for terminating the hole.

The location is close to the border between Vulcan Group and Phillips leases so that both could be evaluated. The hole is actually on Vulcan Group leases to possibly earn one-half interest in a section of Vulcan Group land. Also this hole is located near the eastern edge of the hydrothermally altered area and gives deeper temperature data for the area east of strat. test #1.

A lithologic log of strat. test #3 is shown on Plate 6. Alluvium is present to a depth of 110 feet. Below 110 feet hydrothermally altered rhyolite and obsidian are present. The alteration ranges from moderate to intense. The alteration is particularly intense between 240 and 290 feet. At 260 and 290 feet there were lost circulation problems during drilling.

Temperature profiles of strat. test #3 are shown on Plate 7. There are two temperature reversals at 150 feet and 290 feet. These reversals are decreasing with time so are interpreted to be the result of lost drilling fluid equilibrating with the surrounding rock. Below 360 feet the temperature profile is extremely linear with a gradient of 3.29°F/100 feet. Once again, it is risky to assume this gradient can be accurately extrapolated to much greater depths. The hole is simply too shallow.

Strat. Test #4

Strat. test #4 is located in NW $\frac{1}{4}$ NE $\frac{1}{4}$ Section 9, T24S-R23E. Between August 11 and 26, 1980 it was drilled to a depth of 1945 feet with minor lost circulation problems.

The hole was located to evaluate Vulcan Group leases in the hydrothermally altered area south of strat. test #1.

A lithologic log of strat. test #4 is shown on Plate 8. This strat. test encountered the greatest variety of lithologies yet known in any drill hole at Glass Buttes. Above a depth of 1250 feet three thick rhyolite flows are interbedded with interbedded basalt flows and sediments. The sediments consist of sand, silt, gravel and tuffaceous sediments. Below 1250 feet the hole encountered rhyolite which is generally highly altered and silicified. Above 1250 feet alteration is often present but is generally only moderate in intensity.

This geology suggests that the hole is located in a basin or old valley off to the side of the more recent volcanic activity at Glass Buttes. The thick rhyolite below 1250 feet may represent one of the earlier domes, flows, or vents at Glass Buttes.

Temperature profiles for strat. test #4 are shown on Plate 9. The profiles are linear and suggest no convective movement of water in the area near the borehole. The temperature gradient between 1560 feet and 1945 feet is $2.6^{\circ}\text{F}/100$ feet. Obviously this is not an encouraging strat. test.

Updated Shallow Temperature Gradient Data

Since the original Glass Buttes report was written in 1977 a substantial amount of new temperature data has been obtained and added to the temperature gradient map (Plate 10) and to the 200-foot depth isothermal map (Plate 11).

The temperature-gradient map is based on data collected above a depth of 500 feet. This map shows the Glass Buttes thermal anomaly to correspond well with the outline of the exposed rhyolites (Benoit, 1977). The area of low thermal gradients near the center of the buttes is believed to result from subsurface drainage of meteoric water and is a minor feature. The highest measured thermal gradient at Glass Buttes is $12.9^{\circ}\text{F}/100$ feet in GB-1.

The 200-foot depth isothermal map shows a similiarly-shaped thermal anomaly over Glass Buttes. This anomaly is also similar to the temperature-gradient

anomaly in that it is very large but not intense. The maximum recorded temperature at a depth of 200 feet is 79°F.

In the southeast corner of both maps is a recently discovered thermal anomaly. The boundaries of this anomaly are poorly known due to a lack of data points. However, the gradients and temperatures are similar to those at Glass Buttes. The geology is also similar to Glass Buttes in that perlitically altered obsidian has been found to underly young basalts in drill hole BFZ-57.

Re-interpretation of the Shallow Thermal Anomaly

Now that five strat. tests have been drilled and additional surrounding holes have been probed it is possible and timely to re-interpret the shallow thermal anomaly.

The equilibrium or "closest to equilibrium" profiles available for the five strat. tests are shown on Plate 12. These five profiles show that it is generally risky to project gradients from above 500 feet to greater depths. It is even riskier to attempt to project gradients above a depth of 200 or 300 feet. Unfortunately most of the shallow temperature-gradient holes at Glass Buttes are less than 300 feet deep and are above the water table.

In most cases at Glass Buttes where the temperature gradient changes with depth, the gradient decreases, often greatly. Holes in which there are large gradient changes are shown on Plate 10 with multiple gradients. However, it should be pointed out that most of the holes with large gradient decreases are located around Glass Buttes, rather than within Glass Buttes. In the western half of Glass Buttes there are no deeper holes to serve as a possible check on any extrapolations of the thermal gradients.

It also needs to be pointed out that the thermal anomaly located at the far western end of Glass Buttes is suspect. In hole C-45 the gradient decreases from 8.3°F/100 feet to 3.4°F/100 feet at 240 feet. Three nearby holes, GB 7, 8, and 19

have gradients over $9^{\circ}\text{F}/100$ feet but are quite shallow. It is believed that if these holes were a few hundred feet deeper the gradients shown on Plate 10 would be substantially lower.

In the central part of Glass Buttes the only deeper hole is Francana GB-16. It is located one-half mile south of a 200-foot deep hole with a gradient of $8.1^{\circ}\text{F}/100$ feet. The average gradient of the Francana hole is $4.6^{\circ}\text{F}/100$ feet to a depth of 2000 feet. Clearly the $8.1^{\circ}\text{F}/100$ feet gradient cannot be extrapolated. The Francana hole is the only hole to date which provides unquestionable evidence of moving thermal water at Glass Buttes. The thermal water probably has a temperature of about 120°F . To date there is no data available to outline the extent of this thermal water, its direction of flow, and origin. However, simply the existence of this thermal water provides a basis for some speculation. No samples of this water have been obtained so there is no geochemical data. Without this constraining data it is suspected that the thermal water contains little or no mixed in cold meteoric water for the following reasons. The area is semi-arid and is a topographic high. The water table is deep and there are no permanent springs in the buttes. Thus a source of near-surface cold water for mixing appears to be lacking.

The available data permit this thermal water to be interpreted in at least two different ways. First this thermal water could be local in extent with principally vertical movement up one of the numerous faults in the area. A second interpretation would have the thermal water be part of a subhorizontal thermal aquifer covering an area of perhaps several square miles. In this case the source of the water could be located several miles away from Francana GB-16. If this is the case the water should cool as it moves away from its source. Now if the source of the water is a 400°F geothermal reservoir the aquifer should originally have a temperature near 400°F . Over such an aquifer extremely high temperature gradients should be present. These gradients are simply not present at Glass Buttes. The

only undrilled area large enough to have high unknown gradients is under Glass Butte itself in Section 22, T23S-R22E. The relatively low temperatures around Glass Butte (Plate 11) tend to negate this possibility. Also there is no geologic evidence such as hot springs, siliceous sinter, hydrothermal alteration or mineralization to indicate a geothermal reservoir lies beneath Glass Butte.

Based on the previous discussion a possible and reasonable model of the thermal anomaly is presented. The four strat. tests at the eastern end of the buttes show no moving thermal water above a depth of 2000 feet. The near-surface anomaly at the east end of the buttes is mostly the result of conduction in an environment of near normal temperatures. Strat. test #1 is clearly anomalous at a depth of 2000 feet (see Plate 12). It is not possible, however, to predict the thermal or hydrologic conditions at greater depth. It is possible that a conductive gradient could extend for several thousand more feet or that a reversal or isothermal section could be encountered in a few feet in strat. test #1. No predicted temperatures from chemical geothermometers are available to aid in predicting conditions at greater depth.

In the central part of Glass Buttes the Francana GB-16 hole has shown convective movement of warm thermal water. To the north and east of Francana GB-16, holes GB-1, 9, 15, and 22 have high thermal gradients. It is suspected that in this area warm thermal water could be flowing northward at depths of 400 to 1000 feet.

In the western part of Glass Buttes between GB-5 and GB-8 no strat. tests have been drilled. The thermal anomaly could be due to conduction of heat or be due to one or more small warm thermal systems. At present there is no reason to expect a hot subhorizontal thermal aquifer in this area.

Lastly the unoutlined thermal anomaly in T25S-R24 and 25E is geologically similar to the Glass Buttes anomaly in several respects. It is expected that this anomaly is the result of conduction or a relatively small warm thermal system.

Estimated Depth to 400°F

Work at three prospects in northwestern Nevada; Steamboat, Soda Lake and Desert Peak, has demonstrated that in some prospects the temperature data from near the bottom of strat. tests can be used to estimate the depth to hotter isotherms.

A map showing the estimated depth to the 400°F isotherm at Glass Buttes is shown on Plate 13. The temperature 400°F was chosen simply because it is about the minimum temperature required for power generation. Data used in this estimation are from the temperature profiles on Plate 12. This data is also shown on Table 1 for convenience sake.

Data from strat. tests #1 and #2 and Francana GB-16 cannot be confidently extrapolated as the temperature profiles are not linear at the bottom of the holes. Therefore, Table 1 contains two extrapolations for these holes. In particular the estimated depths vary greatly for strat. test #2. The variation for strat. test #2 ranges from 6300 feet to 14,600 feet. It is suspected that the 6300 foot depth is unrealistically shallow as the temperature gradient substantially decreases at 1080 feet. The 14,600 foot estimated depth is also suspect as it is based on only 100 feet of drill hole data.

Due to the relative uncertainty of the extrapolations the data on Plate 13 has not been contoured. All the extrapolations on Table 1 are shown on Plate 13.

Plate 13 shows a one-point anomaly around strat. test #1 when the 6300 foot extrapolation for strat. test #2 is discounted. The four other holes suggest an average near 12,000 feet for the 400°F isotherm. A 3.3°F/100 feet temperature gradient will reach 400°F at a depth of 12,000 feet. Thermal gradients of 3 or 4°F/100 feet are common background values in the Brothers Fault Zone. Therefore, it is likely that strat. tests #2, 3, 4, and Francana GB-16 represent normal background thermal conditions for the Brothers Fault Zone and Glass Buttes.

The deeper thermal anomaly around strat. test #1 can cover only a couple square miles at best. This leads one to suspect that the anomaly is caused by local

TABLE 1
ESTIMATED DEPTH TO 400°F *

<u>Hole #</u>	<u>Total Depth (Tubing)</u>	<u>Bottomhole Temperature</u>	<u>Temperature Gradient</u>	<u>Depth Interval</u>	<u>Estimated Depth to 400°F</u>
#1	1984'	201°F	6.6°F/100'	1260'-1880'	5,000'
		201°F	5.6°F/100'	1880'-1984'	5,500'
#2	1180'	104°F	5.8°F/100'	600'-1080'	6,300'
			2.2°F/100'	1080'-1180'	14,600'
#3	840'	76°F	3.3°F/100'	400'-840'	10,700'
#4	1945'	122°F	2.6°F/100'	1560'-1945'	12,600'
Francana GB-16	2000'	136°F	3.9°F/100'	1720'-2000'	8,800'
			2.7°F/100'	1900'-2000'	11,800'

* All data on this table is from the profiles on Plate 12

thermal water movement along a fault. All that can be said of the temperature of the water is that it is over 201°F.

Conclusions

1) The most promising geological target at Glass Buttes, the hydrothermally altered and mineralized eastern end of the buttes, has been thoroughly evaluated by four strat. tests. Only one of the strat. tests gives an indication of a possible geothermal reservoir in the area.

2) Francana GB-16 has evaluated the north-central part of Glass Buttes and has demonstrated moving thermal water to be present in the area. This thermal water has a temperature of about 120°F and does not appear to have originated in a 400°F or hotter geothermal reservoir. This moving water may explain a portion of the near-surface thermal anomaly.

3) The large near-surface thermal anomaly at Glass Buttes is misleading. With depth the higher thermal gradients tend to show large decreases.

4) The western half of the near-surface thermal anomaly has not been evaluated by deeper drilling. In light of the existing data there are no compelling reasons for deeper drilling in this area.

5) If a geothermal reservoir is present in the vicinity of strat. test #1 it is probably very small. Any large geothermal reservoir must be quite deep. Drilling deep holes at Glass Buttes will likely be very expensive in the hard and quite permeable volcanics.

6) The recently discovered thermal anomaly southeast of Glass Buttes is believed to be very similar to the Glass Buttes anomaly. It is unlikely that a viable geothermal reservoir is present in this area.

7) There is no geochemical data to provide encouragement by suggesting a 400°F or hotter geothermal reservoir is present.

Recommendations

1) No additional drilling is recommended at Glass Buttes. There is a small chance that a geothermal reservoir is present near strat. test #1 but the other strat. tests suggest any reservoir would be small.

2) No additional drilling is recommended in the recently discovered thermal anomaly in T25S-R24 and 25E. This anomaly is known only to Phillips and it is highly unlikely to be discovered by competitors. If any future developments at Glass Buttes are promising leases should be obtained in this area.

3) Phillips should relinquish all its Federal and state leases at Glass Buttes in order to free up Federal acreage for new prospects in Oregon.

4) Phillips should inform the Vulcan Group that no deep test will be drilled, making the Vulcan-Phillips agreement void.

5) Phillips should abandon all drill holes at Glass Buttes.

BIBLIOGRAPHY

Benoit, W. R., 1977, Report on the Glass Buttes, Oregon Geothermal Prospect:
Phillips Petroleum Company Report, 36 pp.

APPENDIX A

DAILY REPORT DETAILED

LEASE Glass Buttes

WELL NO. Strat #1

SHEET NO. 1

DATE	TOTAL DEPTH	NATURE OF WORK PERFORMED
12-08-77	43	Drilling rhyolite, basalt, obsidian. Loc: 1500' FN&WL Sec. 33-23S-23E, Lake Co., Oreg. 2000' temp. observation well. Job E-1273, PPCo. 100% Dixie Drlg. Co., contractor. Elev: G1 4900, RKB 4905. Spdd. 8 1/2" hole at 5:45 pm 12-07-77.
12-09-77	90	Drilling basalt. Mud 9.0, Vis. 47, LCM 3%. Had water flow at 47', lost circulation at 48'. Mixed mud & LCM, full returns. Trip for bit at 49'.
12-10-77	167	Circulating and conditioning hole. Drld. 8 1/2" hole to 167', circulated & conditioned hole 4 hrs. Flow line temperature 54°F.
12-11-77	167	Woc. Pulled out of hole. Ran 5 jts., 161.72', 7" OD, 20#, 8R, K-55, ST&C Csg., set at 160.72' RKB. Cemented with 65 sacks Portland cement w/3% CaCl ₂ . Pumped plug to 127' at 12:35 pm 12-10-77, good cement returns to surf.
12-12-77	246	Drilling sand & conglomerate. Cut off 7" casing, nipples up, installed 6" 900 Ser Single gate BOP. Went in hole w/3 DC's & 1 jt. 2 7/8" DP. Tested csg. & BOP to 375#, 10 mins., OK. (Witnessed by BLM & State) Drld. cement 76-162'. Started 6 1/4" hole at 162'. Flow line temp. at 246'-52°F.
12-13-77	550	Drilling quartzite. Trip for bit at 286'. Mud 8.9, Vis. 42. Flow line temp. at 550'-60°F.
12-14-77	703	Drilling volcanics. Trip for bit at 568'. Mud 9.2, Vis. 40. Flow line temps: 606'-67°F; 623'-68°F; 655'-69°F; 703'-69°F.
12-15-77	868	Drilling volcanics. Lost returns at 826'. Mixed mud & LCM, full returns in 4 3/4 hrs. Trip for bit at 833'. Mud 8.8, Vis. 42, LCM 10%. Flow line temp: 731'-72°F; 832'-58°F; 868'-57°F.
12-16-77	1106	Mixing mud. Lost complete returns at 896', approx. 45 bbls. Mixed mud-LCM pill, spotted on bottom, regained circulation. Losing partial circulation 109--; -6', pulled up to mix mud & LCM. Mud 9.0, Vis 44, LCM 15%. Flow line temp: 897'-56°F, 943'-59°F; 1000'-60°F; 1057'-64°F, 1090'-68°F; 1106'-69°F.

DAILY REPORT DETAILED

LEASE Glass Buttes

WELL NO. Strat #1

SHEET NO. 2

DATE
NATURE OF WORK

TOTAL
DEPTH
PERFORMED

12-17-77	1311	Drilling altered obsidian. Mud 9.2, Vis. 42, losing some mud. Flow line temps: 1176'-68°F; 1260'-68°F; 1300'-73°F.
12-18-77	1488	Repairing rig. Swivel bearing seized at 1:00 p.m. Pulled out of hole. Flow line temps: 1366'-75°F; 1404'-74°F; 1488'-74°F.
12-19-77	1488	Repairing rig 24 hours.
12-20-77	1488	Repairing rig.
12-21-77	1488	Shut down for rig repairs. Thawed out pits. Ran in 5 stands, attempted to circulate ice plugs in DP & bit, blew out rotary hose & broke cross-head on pump. Pulled up into surface casing. Shut down for repairs.
12-29-77 thru 1-03-78	1488	Repairing rig.
1-04-78	1488	Reaming hole at 1360'. Finished repairing rig. Thawed pits, mixed mud. Went in hole, broke circulation at 160', drilled bridges at 688' and 828'. Reamed 827-1360'. Flow line temps. 688'-68°F, 828'-69°F, 1360'-79°F.
1-05-78	1807	Repairing drilling line. Reamed 1360-1488'. Mud 9.3, Vis 45. Flow line temps. 1550'-76°F out. 1600'-64°F in 80°F out 1753'-48°F in 90°F out.
1-06-78	2007	Altered obsidian, laying down drill pipe. Drilled 6 1/4" hole to 2007' at 11:00 pm 1-5-78. Circulated 2 3/4 hrs. Started laying down drill pipe. Flow line temp: 1848'-61°F in, 94°F out; 1920'-60°F in, 97°F out; 1980'-62°F in, 99°F out; 2007'-60°F in, 104°F out.
1-07-78	2007	Complete as temperature observation well. Laid down drill pipe. Ran 63 jts., 2 7/8" OD tubing, set at 1986' RKB. Filled tubing with water. Job complete at 7:00 pm 1-06-78.

FINAL REPORT

RECEIVED

FILED

2530

DAILY REPORT DETAILED

LEASE Glass ButtesWELL NO. Strat #2SHEET NO. 1

DATE
NATURE OF WORK PERFORMED

TOTAL
DEPTH

DATE	TOTAL DEPTH	NATURE OF WORK PERFORMED
7-20-80	200	<p>Lost circulation.</p> <p>Location: 1320' FEL & 106' FSL, Sec. 22-23S-23E Lake Co., Oregon. 2000' Temperature Observation well. Job E-1273. PP Co-100%-oper. Aqua Drilling-contr. MI & RUR. Elev: GL 5600 RKB 5604. Spudded 9 7/8" hole at 11:00 am 7-19-80; drilled to 200', lost circulation. Flow line temps: 190'-61° in, 62° out, 200' - 62° in, 63° out.</p>
7-21-80	325	<p>Running 7" casing..</p> <p>Drilled sand, gravel & basalt. Mud 9.4, Vis 45. Mixed mud & LCM 8 hrs. Flow line temp: 220'- 62° in, 63° out; 240'-62° in, 63° out; 260'-62° in, 63° out; 280' - 62° in 63° out; 300'-62° in, 63° out; 325-62° in, 63° out.</p>
7-22-80	325	<p>WOC.</p> <p>Ran 10 jts, 307.42' LTM, 7" OD. 20#, K-55, R-2. ST & C casing, condition "A". Set at 309' RKB. Cemented with 100 sx common redimix cement w/3% Cacl₂. Pumped plug to 279' RKB at 12:30 pm 7-21-80. Good cement returns to the surface.</p>
7-23-80	600	<p>Tripping for new bit.</p> <p>WOC, cut off 7" casing, welded on 6"900 series single gate BOP. Pressured BOP & casing to 300#, 20 mins, held OK. Test witnessed by State Engineer Burn Newton. Drill cement and shoe. Started 6 1/2" hole at 325'. Flow line temps: 420'-75° in, 75° out; 460'-75° in, 75° out; 500'-73° in, 74° out, 560'-73° in, 74° out; 600'-72° in, 73° out.</p>
7-24-80	880	<p>Drilling volcanic ash and gravel.</p> <p>Mud 9.3, Vis 40, LCM 6%. Flow line temps: 620'-72° in, 73° out; 660'-72° in, 73° out; 700'-72° in, 72° out; 820'-78° in, 80° out; 880'-79° in, 80° out.</p>
7-25-80	1160	<p>Drilling quartz & obsidian.</p> <p>Mud 9.2 Vis 38, LCM 3%. Flow line temps: 920'-79° in 80° out. 960'-76° in, 76° out; 1000'-76° in, 76° out; 1020'-75° in, 76° out; 1060'-76° in, 76° out; 1100'-79° in 80° out; 1120'-80° in, 81° out; 1160'-80° in, 81° out. Adding water while drilling.</p>
7-26-80	1220	<p>Lost circulation.</p> <p>Mud 9.3, Vis 60, LCM 15%. Drilled 6 1/2" hole to 1180', lost circulation, mixed mud & LCM, regained circulation. Drilled to 1220' and lost complete returns. Mixed 100 Eblis 15% LCM, staged in hole through open ended DP at 300', no fill up. Flow line temps: 1200'-78° in, 80° out. 1220'-78° in, 80° out.</p>

DAILY REPORT DETAILED

LEASE Glass ButtesWELL NO. Strat #2SHEET NO. 2

<u>DATE</u>	<u>TOTAL DEPTH</u>	<u>NATURE OF WORK PERFORMED</u>
-------------	------------------------	---------------------------------

7-27-80

1220

Lost circulation.

Pumped in approximately 650 Bbls of 60 Vis, 18-20% LCM. Hole would fill and then recede down hole. Went in hole with bit, lost returns at 500', unable to fill hole. Went to TD, hole clean and free. Pumped in 40 Bbls, 60 Vis, 20% LCM, no returns. Pulled out of hole. Reran DP open ended to 300'. Batch treated, pumping in 10-15 Bbls every 10-15 mins.

7-28-80

1220

TD & MOR

Pumped in approxiamtely 275 Bbls. 60 vis, 15-20% LCM, no returns. Hole stable for 10 mins, then receded, unable to fill hole. Mixed 2 pits of mud, 60 vis, 18-20% LCM unable to fill hole. Ran 39 jts, & 1-5' Muleshoeed jts, 1206.90' LTM, 2 7/8" PD, 6.5#, J-55, EUE tubing, Set at 1216' RKB. Removed BOP, landed tubing in hanger and filled with fresh water. Pumped 65 Bbls fresh water annulus. Released rig at 12 noon 7-27-80 Well completed for temperature observation. FINAL REPORT

DAILY REPORT DETAILED

LEASE Glass ButtesWELL NO. Strat #3SHEET NO. 1

DATE
NATURE OF WORK PERFORMED

TOTAL
DEPTH

7-29-80	290	<p>Lost circulation.</p> <p>Loc: 2375' FN & WL Sec 35-23 S-23E, Lake County, Oregon</p> <p>2000' Temperature Observation Well. Job E-1273. YPCo</p> <p>100% oper. Aqua Drilling Co., Contr. MI & RUR. Elev:</p> <p>G1 5300, RKB 5304. Spudded 9 7/8" hole at 3:30 p.m.</p> <p>7-27-80. Drilled to 260', lost complete returns. Regaine</p> <p>returns and drilled to 290', lost returns mixing 8.8 mud,</p> <p>Vis 45, 15-20% LCM, hatch treat.</p>
7-30-80	OTD 290 PTD 172	<p>WOC</p> <p>Mixed 4 pits mud, 18-20% LCM. Batch treat thru open</p> <p>ended DP w/approximately 640 Bbls, no fill up. POOH.</p> <p>Dumped dry LCM in hole and ran approximately 200 Bbls</p> <p>water in hole, filled hole. Went in hole w/DP to 100',</p> <p>lost returns. Pulled out of hole and reran DP open ended</p> <p>to 200." Pumped in 40 Bbls water, hole on vacuum. Pulled</p> <p>up to 100', fluid down hole 55'. Pumped in 100 sx neat</p> <p>common cement, 4% Cacl₂, approximately 150' slurry, went</p> <p>in on vacuum. Job complete at 9:30 am 7-29-80. WOC 5</p> <p>hrs. Went in w/DP, top of cement at 172', filled hole</p> <p>and could circulate. WOC</p>
7-31-80	OTD 290 PTD 277	<p>WOC.</p> <p>Went in hole w/9 7/8" bit to top of cement at 172',</p> <p>drilled to 277' w/full returns. Pulled out of hole.</p> <p>Ran 9 jts, 267.31' LTM, 7" OD, 20#, K-55, 8R, ST & C</p> <p>casing set at 268' RKB. Cemented with 85 sx Redimix</p> <p>cement, 3% Cacl₂. Pumped plug to 242' at 2:45 pm</p> <p>7-30-80. Full returns until near end of mixing.</p> <p>Regained returns while pumping for a few minutes and</p> <p>lost returns. No cement to surface.</p>
8-1-80	OTD 290 PTD 277	<p>Shut down.</p> <p>Cut off 7" casing. Welded on 6" 900 Bradenhead, installed</p> <p>6" 900 single gate BOP and flow nipple. Shut down at</p> <p>2:00 pm 7-31-80, crews off 5 days.</p>
8-5-80	OTD 290 PTD 277	<p>Shut down, crews off.</p>
8-6-80	460	<p>Drilling obsidian & Basalt?</p> <p>Drilling with air & foam. Went in hole w/6 1/2" bit, drilled</p> <p>plug & insert, drld cement to 250'. Tested BOP & casing</p> <p>to 300#, bled to 280# in 10 mins. Released pressure,</p> <p>repressured to 410#, bled to 405# and held for 10 mins</p> <p>at 405# OK. Test witnessed by Dennis Davis, BLM. Drilled</p> <p>shoe and cement to 290'. Started 6 1/2" hole at 290', lost</p> <p>returns. Drld to 300' with mud & LCM, no returns. Con-</p> <p>verted to air & foam, drilling ahead.</p>

DAILY REPORT DETAILED

LEASE Glass ButtesWELL NO. Strat #3SHEET NO. 2

DATE	TOTAL DEPTH	NATURE OF WORK PERFORMED
8-7-80	760	<p>Lost Circulation.</p> <p>Drilled with air & foam to 700', hit water zone. Treated with water control gel and drilled to 760', water too high to keep hole clean. Pulled out of hole. Batch treated down open hole with approximately 230 Bbls at 8.7# mud, 45 Vis, 15-20% LCM, no fill-up.</p>
8-8-80	840	<p>Lost circulation.</p> <p>Mixed mud & LCM and dumped in hole, started filling at 9:00 pm. Let set 3 hrs, filled hole. Went in hole, drilled to 840', lost circulation. Mixed mud and LCM 20-25%, batch treated hole.</p>
8-10-80	840	<p>WOC.</p> <p>Batch treat with approximately 400 Bbls Mud & LCM. Filled hole at 900 pm 8-9-80, standing full. Went in with bit, broke circ at 200' intervals, hole broke down at 500', lost complete returns. Pulled out of hole, went in hole open end to 240'. Pumped in 80 sx cement, 3% Cal₂, went in on vacuum. Job complete at 12:45 am 8-10-80. WOC 3 hrs, tagged top of cement at 175', WOC.</p>
8-11-80	840	<p>TD & MOR.</p> <p>Drld cement 175'-290', lost complete returns. Filled out of hole. Pumped in 275 Bbls mud & LCM, could not fill hole. Ran 27 fts, 834.55' LTM, 2 7/8" OD 6.5#. J-55. EUE tubing, set at 840' RRB. Landed in braden-head, filled with fresh water. Released rig at 4:00 pm 8-9-80. Well completed for temperature observation.</p> <p><u>FINAL REPORT.</u></p>

DAILY REPORT DETAILED

LEASE GLASS BUTTESWELL NO. STRAT #4SHEET NO. 1

DATE	TOTAL DEPTH	NATURE OF WORK PERFORMED
------	----------------	--------------------------

8-11-80 140

Drilling Clay.

Loc: 1050' FEL & 800' FNL, Sec 9-24S-23E. Lake Co, Oregon 2000' Temperature observation well. Job E-1273. PPCO 100%, oper. Aqua Drilling Co., contr. MI & RUR. Elev: G1 4550, RKB 4554. MI & RUR. Spudded 9 7/8" hole at 9:30 am 8-10-80.

8-12-80 365

WOC

Drilled 9 7/8" hole to 365'. Circulated and conditioned hole. Ran 11 fts, 342.07' LTM, 7" OD, 20#, K-S.5, 8R ST & C Casing set at 343' RKB. Cemented w/80 sx common cement, 3% CaCl₂. Pumped plug to 310' at 11:55 am 8-11-80, good cement returns to surface. WOC

8-13-80 440

Drilling volcanics.

Cut off 7" casing. Welded on 6" 900 Bradenhead, installed 6" 900 single gate BOP. Drilled plug, insert and cement to 325'. Pressured BOP & casing to 400#, held at 380", 40 mins, OK. No State or BLM representative showed up. Drilled cement & shoe at 1:30 pm 8-12-80. Started 6 1/2" hole at 365'.

8-14-80 680

Drilling volcanics.

Mud 9.1, Vis 41, LCM 3%. Flow line temp at 680' - 61° out.

8-15-80 820

Drlg Volcanics.

Mud 9.4, Vis 45, LCM 20%. Lost complete circulation @ 815'. COOH w/bit. Batch treat down csg - hole filled. Reran bit & drlg ahead @ 820'.

8-16-80 930

Drilling volcanics.

Mud 9.3, Vis 32, LCM 5%. Flow line temp @ 930' - 60°

8-17-80 1030

Drilling volcanics. Mud 9.8, Vis 45, LCM 15%. Drilled to 1010' - lost circ. POOH & regained circ. Batch treating down top csg. Ran bit #4 @ 1010'. Flow line temps: 980 - 60°, 1010' - 64°.

8-18-80 1125

Drilling volcanics.

Mud 9.4, Vis 45, LCM 8%. COOH @ 1125' to replace bit #4. Flow line temp @ 1100' - 62°.

8-19-80 1260

Tripping for bit.

Drl'd clay to 1260'. Mud 8.6, Vis 39. Flow line temp @ 1252' - 69° in, 71° out.

DAILY REPORT DETAILED

LEASE GLASS BUTTESWELL NO. STRAT #4SHEET NO. 2

DATE	TOTAL DEPTH	NATURE OF WORK PERFORMED
------	----------------	--------------------------

8-20-80	1350	Lost Circulation. Mud 8.6, Vis 35. Lost circulation at 1350'. Mixed 2 heavy mud pills, pumped in hole, plugged bit. Pulled out of hole. Staging in hole with LCM pill, break circulation every 100', now circulating at 800'.
8-21-80	1600	Drilling volcanics. Mud 8.9, Vis 41, Flow line temp 64° in, 66° out.
8-22-80	1860	Drilling altered clay. Mud 8.9 in, 9.2 out, Vis 42. Flow line temps 1860'-74 in, 76° out. Found old thermometer reading 17° low.
8-23-80	1945	Waiting on repairs. Drilled 6½" hole to 1945', transfer case went out on unit. Shut down, waiting on parts. Flow line temp at 1925', 74° in, 81° out.
8-24-80	1945	Circulating and working stuck drill pipe. Repaired rig at 9:00 pm 8-23-80. Circulated & worked stuck drill pipe. Flow line temp 81°.
8-25-80	1945	Running tubing. Worked drillpipe, spotted 150 gals chemical, worked pipe 6 hours. Spotted 40 bbls Diesel oil & 55 gals EZ Spot, worked free at 6:00 pm. Pulled out of hole. Rigged up and started running tubing.
8-26-80	1945	Completed for temperature observation. Ran 64 Jts, 2 7/8" OD, 6.5#, J-55, EUE tubing, set at 1941.48' RKB. Filled tubing with water. Complete for temperature observation. TD & NIOR. <u>Final Report</u>

FRANCANA GLASS BUTTE #16
(Geothermal Temp. Gradient Well)

Location - SW19 - T23S - R23E - Oregon

Fri. 8/31/79 - Move in, spud at 3 P.M. Drill to 100'. Drilling with air, encountered water from 60 to 100'.

Sat. 9/1/79 - Wait on backhoe to ^{dig} drill mud pits. Haul water and mix mud. Drill to 120', strong water entry, cutting mud. Basalt gravel caving on top of bit, caused plugging. Trip four times to clean bit.

Sun. 9/2/79 - Drill ~~to~~ 120 to 230'. Water entry from 60 to 160'. Hole caving 120 to 160'. Drill 230 to 240'. Pull out and run 7" casing, landed at 228'. Stand-by waiting for cement.

Mon. 9/3/79 - Stand-by all day waiting on cement due to Labor Day holiday, no supplier would deliver.

Tues. 9/4/79 - Waiting to cement until 11 A.M. Tried to establish circulation, could not due to plugging. Trip into hole with drill pipe and established circulation. Cement casing, wait on cement, rig up BOP, dig cellar.

Wed. 9/5/79 - Completed rigging up BOP, pressure test approved by Oregon State representative. Drilled out and at 2100 hrs. depth 680'. Drilled mainly obsidian to 580' at which point lost mud returns. Drilled blind to 670 then switched to air-foam.

Thurs. 9/6/79 - Depth at 2000 hrs., 820'. Drilled 670 to 710 with air-foam, at which point the technique became ineffective. Started mixing mud and lost circulation material (cotton seed hulls) and drilled blind to 820'. Trip to check bit.

Fri. 9/7/79 - Depth at 1900 hrs. - 920'. Drilled blind 820 to 920'; mixing mud and lost circulation material.

Sat. 9/8/79 - Depth at 2400 hrs. - 1130'. Drilling blind, 920 - 930 basalt, 930 - 1130 clay, apparent lake deposit. Only samples taken from bit on trips.

Sun. 9/9/79 - Depth at 2400 hrs. - 1320'. Drilling blind, formation alternating clay, sandstone basalt, tuff and welded tuff. Only samples from bit, on trips.

Mon. 9/10/79 - Depth at 0800 hrs. - 1385'. Drilling blind.

Tues. 9/11/79 - Depth at 0800 hrs. - 1630'. Drilling blind, formation hard sandstone, consisting of volcanic rock fragments. Circulating and rotating on bottom, waiting for parts to repairs blocks as of 2000 hrs.

Wed. 9/12/79 - Parts arrived and back to drilling at 1700 hrs. Depth at 2100 hrs. - 1700'. Ran temperature log on Musser water well. Temperature 87.9° F at depth 580'.

Francana Glass Butte #16

Page 2

Thurs. 9/13/79 - Depth as of 2400 hrs. - 1940'. Pulling to clean plugged bit when rig transmission failed.

Fri. 9/14/79 - 0800 hrs. - waiting on rig parts.

Sat. 9/15/79 - Waiting on rig parts.

Sun. 9/16/79 - Waiting on rig parts.

Mon. 9/17/79 - 0800 hrs. - waiting on rig parts.
Rig repaired at 2000 hrs., picked up and started out of hole.

Tues. 9/18/79 - 0900 hrs. - depth at TD 2000', mixing mud and conditioning hole to run casing.

Wed. 9/19/79 - Report at 1400 hrs. Completed initial logging program. Logging tools would not go below 1600'. Temperature 120 degrees F. at 1600'. Ran 2" casing to total depth. Rigging down and cleaning up lease. Rig released at 1500 hrs.

APPENDIX B

Cascadia Exploration Corporation

Consulting Geologists

Eugene V. Ciancanelli, Registered Professional Geologist, President

3358 Apostol Road, Escondido, California 92025 (714) 489-0969

LITHOLOGIC LOG

FRANCANA GLASS BUTTE TEMPERATURE GRADIENT WELL GB-16

Location: Glass Butte, Lake County, Oregon

Company: Francana Resources, operator for the Vulcan Group

Drilling Contractor: Geothermal Services, Inc.

Logged by: Eugene V. Ciancanelli

Spudded: 8-31-79 Finished: 9-19-79

Total Depth: 2052 feet

LITHOLOGY

alluvium

obsidian

perlite rhyolite and perlite obsidian

rhyolite

clay

volcaniclastic sandstone

PROJECT GLASS BUTTE, OREGON HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 feet.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	0		0-10' Alluvium-fragments red and black obsidian & gray & white rhyolite. Angular cuttings derived from cobbles and boulders a few rounded sand size fragments.		
	10		Diversity of lithology, weathering & rounding indicate alluvium		
	20		10-20' <u>Obsidian</u> color banded moderate reddish brown 10R 4/6 w/streaks grayish black N2 to transparent gray. Some reddish brown obsidian has autoclastic to perlitic texture.	obsidian and perlitic rhyolite to perlitic obsidian tends to drill as sugary textured glass splinters.	
	30		20-60' Obsidian-glassy reddish brown 10R 4/6 w/streaks grayish black N2 to transparent gray. The darker colored streaks become more prevalent toward the bottom of this interval. Some crushed glass toward the bottom of this interval but no devitrification of the glass.		
	40		60-290' <u>Rhyolite</u> , medium gray N5, tiny gray spots could be feldspar xls. or lithophysae. All rhyolite fragments are iron oxide stained. This suggests water movement. The abrupt change from obsidian to rhyolite suggests faulting, but transition from obsidian to rhyolite in a single flow can occur across a "knife edge" contact. The oxidation to iron may be after very finely disseminated pyrite.	@60' began to get water entry, possible fault zone. Driller put water entry zone 60-160' but water entry continued below 160'. Drilled with air to 100' then switched to mud.	
	50		80-90' again as at 60' evidence of faulting occurs as crushing and destruction of original rhyolite textures, present in 5-10% of fragments.		
	60		At approximately 110' began to get streaks of grayish black N2 to transparent gray <u>obsidian</u> .		
	70				
	80				
	90				
	100				
	110				
	120				
	130				
	140		@140-150' some streaks moderate reddish brown 10R 4/6 <u>obsidian</u> w/ <u>perlitic</u> or autoclastic texture.		
	150				

PROJECT GLASS BUTTEHOLE NO. GB-16LOCATION Glass Butte, Lake County, Oregon

COLLAR EL. _____

COMPANY Francona ResourcesTOTAL DEPTH 2052 feetCONTRACTOR Geothermal ServicesSPUDDED 8-31-79 FINISHED 9-19-79LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	150		160-190' Downward increase in percentage of obsidian to 40% and rhyolite 60%. Color varieties remain the same. Some transparent obsidian contains euhedral feldspar xls. which appear to be sanidine. 170-180' minor evidence of faulting includes crushed obsidian & slickensided fragment.		
	160				
	170				
	180				
	190		190-200' 80% rhyolite & 20% obsidian		
	200		200-220' Slightly greater percentage of obsidian. In this interval detected metallic gold colored mineral in couple of fragments. These gold specks were at the limit of microscopic detection. This could be pyrite, light reflection or even gold. Took sample for gold geochem analysis. If anomalous other intervals should be checked.		
	210				
	220				
	230		220-250' 60% obsidian & 40% rhyolite.	228' shoe 7" casing	7"
	240		250-260' 20% rhyolite, 40% obsidian & 40% perlite obsidian to perlite rhyolite. The perlite rhyolite white in color contains a black acicular mineral possibly hornblende. The perlite fragments vary in color from white N9 to moderate reddish brown 10R 4/6, the rhyolite & obsidian occur in the colors described above.		
	250				
	260				
	270		260-270' 40% rhyolite, 20% obsidian 30% perlite rhyolite & obsidian. Some breccia fragments.		
	280		270-280' 50% obsidian & 50% perlite rhyolite & obsidian.	290-360' perlite drills into fine sugar like glass splinters.	
	290		280-290' 50% rhyolite, 25% obsidian & 25% perlite rhyolite & obsidian.		
	300		290-360' perlite rhyolite & obsidian.		

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	300		ian varies in color from white N9 to moderate reddish orange 10R 6/6		
	310				
	320		@320' primarily white perlitic rhyolite & obsidian with minor pink to orange shades.		
	330				
	340		@340' began to get some pink to orange shades of perlitic rhyolite and obsidian.		
	350				
	360		360-390' Rhyolite, obsidian and perlite like in the interval 160-290'. There are present equal amounts of each lithologic type.		
	370				
	380				
	390		390-400' primarily reddish colored perlitic rhyolite.		
	400		400-410' rhyolite medium dark gray N4 some minor white N9 to moderate orange pink 10R 7/4 perlitic rhyolite & obsidian		
	410		410-430' primarily perlitic rhyolite with minor rhyolite.		
	420				
	430		430-460' perlitic rhyolite white, pink & orange shades & transparent obsidian minor in upper zone.		
	440				
	450				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	450				
	460		460-500' mostly pale orange color becomes darker orange downward to 500'		
	470				
	480				
	490				
	500		@500' about equal amounts of orange and white perlitic rhyolite and obsidian		
	510		510-530' orange perlitic rhyolite and obsidian.		
	520				
	530		530-570' same as 500-510'		
	540				
	550				
	560				
	570		570-660' No Sample, driller reported lost circulation at 580' but no samples below 570'	@ 570-580' lost circulation.	
	580				
	590				
	600				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	600				
	610				
	620				
	630				
	640				
	650				
	660		660-680' Rhyolite, thinly laminated flowbands pale red 5R 5/2, medium light gray N6 to medium dark gray N4. Presence of lithophysae and strong iron oxide staining possibly indicates faulting in zone of lost circulation.	@660' switched to foam & got returns drilled with foam to 710' but too much water entry, switched back to mud.	
	670		680-700' Rhyolite same as 660-680' but now laminated with thin laminae of obsidian & perlite obsidian laminae are 1-0.1mm thick. Perlite obsidian light bluish gray 5B 7/1, obsidian is dark gray N3 & moderate reddish brown 10R 4/6 color bands.		
	680		700-710' Rhyolite light gray N7 to white N9. Rhyolite not laminated but is round patches 1 mm or less in diameter of various gray shades in a light gray opalized or glassy matrix.	@710' switched back to mud & lost circulation.	
	690		710' No Sample		
	700				
	710				
	720				
	730				
	740				
	750				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	750		NO SAMPLE - lost circulation		
	760				
	770				
	780				
	790				
	800				
	810				
	820				
	830				
	840				
	850				
	860				
	870				
	880				
	890				
	900				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	900				
	910				
	920				
	930				
	940		@940' removed bit from hole, bit plugged with clay. Clay is grayish orange 10R 7/4 to pale yellowish brown 10YR 6/2. Fragments of other volcanic rock fragments plus glass and rhyolite in a clay matrix. This could be a lake sediment or a tuff.		
	950				
	960				
	970				
	980				
	990				
	1000				
	1010				
	1020				
	1030				
	1040				
	1050				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	1050		NO SAMPLE - lost circulation		
	1060				
	1070				
	1080				
	1090				
	1100				
	1110				
	1120				
	1130				
	1140				
	1150				
	1160				
	1170				
	1180				
	1190				
	1200				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francona Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	1200				
	1210				
	1220		<p>@1220' bit plugged and upon removal from hole it was found to contain greenish black cuttings. These cuttings appear to be altered volcanoclastic sandstone. The rock appears to be volcanic mineral fragments and rhyolitic glass. The fragments show strong alteration to celadonite. The drilling rate and these cuttings suggest a layered sedimentary environment.</p>		
	1230				
	1240				
	1250				
	1260				
	1270				
	1280				
	1290				
	1300		<p>@1300' a sample was recovered from the bit. The sample was all light colored glass shards believed to be material caved from higher in the hole.</p>		
	1310				
	1320				
	1330				
	1340				

PROJECT GLASS BUTTE HOLE NC. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francona Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	1350		NO SAMPLE		
	1360				
	1370				
	1380				
	1390				
	1400				
	1410				
	1420				
	1430				
	1440				
	1450				
	1460				
	1470				
	1480				
	1490				
	1500				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francona Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
1500				
1510				
1520				
1530				
1540				
1550				
1560				
1570				
1580				
1590				
1600				
1610				
1620				
1630				
1640				
1650				

PROJECT GLASS BUTTE HOLE NO. GB-16
 LOCATION Glass Butte, Lake County, Oregon COLLAR EL. _____
 COMPANY Francana Resources TOTAL DEPTH 2052 ft.
 CONTRACTOR Geothermal Services SPUDDED 8-31-79 FINISHED 9-19-79
 LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	1650		NO SAMPLE		
	1660				
	1670				
	1680				
	1690				
	1700				
	1710				
	1720				
	1730				
	1740				
	1750				
	1760				
	1770				
	1780				
	1790				
	1800				

PROJECT GLASS BUTTEHOLE NO. GB-16LOCATION Glass Butte, Lake County, Oregon

COLLAR EL. _____

COMPANY Francana ResourcesTOTAL DEPTH 2052 ft.CONTRACTOR Geothermal ServicesSPUDDED 8-31-79 FINISHED 9-19-79LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	1800		NO SAMPLE		
	1810				
	1820				
	1830				
	1840				
	1850				
	1860				
	1870				
	1880				
	1890				
	1900				
	1910				
	1920				
	1930				
	1940				
	1950				

PROJECT GLASS BUTTE

HOLE NO. GB-16

LOCATION Glass Butte, Lake County, Oregon

COLLAR EL. _____

COMPANY Francana Resources

TOTAL DEPTH 2052 ft.

CONTRACTOR Geothermal Services

SPUDED 8-31-79 FINISHED 9-19-79

LOGGED BY Eugene V. Ciancanelli

TEMPERATURE °C	DEPTH	LITHOLOGY	DESCRIPTION	NOTES	CASING
	1950				
	1960				
	1970				
	1980				
	1990				
	2000		2052' T.D. A considerable amount of slough accumulated in the bottom of the hole and kept plugging the bit. A sample recovered contained assorted rock and mineral fragments including a dark greenish gray SG 4/1 fragment which was an altered volcanic rock, possibly a tuff. All of the fragments appear to be derived from silicic volcanic rocks and not mafic volcanic rocks. Fragments of obsidian & perlite rhyolite include red, brown, black and transparent glass. Feldspar & biotite xls. Small black obsidian spheroids with perlite shells. Fragments are indicative of ash flow tuffs particularly the Devine Canyon Ash Flow Tuff. The lower part of the hole is probably ash flow tuffs interbedded with sediments probably lacustrine sediments.	2052' of 2" pipe to T.D.

NOTE: THE ENTIRE RHYOLITIC SECTION IN THIS HOLE IS PROBABLY A SERIES OF GLASSY OBSIDIAN FLOWS. NO UNIQUE MARKER BEDS WERE DETECTED. NO PYROCLASTICS WERE NOTED. MOST OF THE SAMPLES SHOWED AT LEAST SLIGHT HYDROTHERMAL ALTERATION

ALTERATION:

Lithologic Log of Glass Buttes

STRATIGRAPHIC TEST NO. 1

LOCATION: SW 1/4, NE 1/4, Section 33, T23S, R23E, LAKE COUNTY, OREGON

DATE STARTED: 12/7/77

DATE COMPLETED: 1/6/78

NOTE: THE ENTIRE BEDROCK SECTION CONSISTS OF A SERIES OF RHYOLITE LAVA FLOWS. NO MARKER BEDS WERE DETECTED BY EXAMINATION OF THE CUTTINGS OR THE GAMMA AND ELECTRIC LOGS.

ALTERATION:

	SLIGHTLY ALTERED
	MODERATELY ALTERED
	INTENSELY ALTERED

Lithologic Log of Glass Buttes

STRATIGRAPHIC TEST NO. 2

LOCATION: SE $\frac{1}{4}$, SE $\frac{1}{4}$, Section 22, T23E, R23E, LAKE COUNTY, OREGON

DATE STARTED: 7/19/80

DATE COMPLETED: 7/28/80

NOTE: THE BEDROCK GEOLOGY IN THE HOLE CONSISTS OF A FEW RHYOLITE LAVA FLOWS. THERE ARE NO IDENTIFIABLE MARKER BEDS DISCERNABLE FROM THE CUTTINGS OR THE GAMMA LOG. MOST OF THE LAVAS WERE ORIGINALLY GLASSY.

ALTERATION:

Lithologic Log of Glass Buttes

STRATIGRAPHIC TEST NO. 3

LOCATION: NW1/4, SE1/4, Section 35, T23S, R23E, LAKE COUNTY, OREGON

DATE STARTED: 7/29/80

DATE COMPLETED: 8/11/80

NOTE: HYDROTHERMAL ALTERATION IS PROBABLY PRESENT IN VARYING DEGREES THROUGHOUT THE ENTIRE HOLE. IT IS NOTICABLY MORE INTENSE AND CONSISTENT IN THE RHYOLITE BELOW 1255'. SEVERAL CONTACTS AND UNITS ON THIS LITHOLOGIC LOG WERE PICKED FROM THE GAMMA LOG.

ALTERATION:

Lithologic Log of Glass Buttes

STRATIGRAPHIC TEST NO. 4

LOCATION: NW 1/4, NE 1/4, Section 9, T24S, R23E, LAKE COUNTY, OREGON

DATE STARTED: 8/11/80

DATE COMPLETED: 8/26/80

Glass Buttes Stratigraphic Tests
Equilibrium Temperature Profiles