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BACA GEOTHERMAL DEMONSTRATION PROJECT

INTERPRETATION OF DOWNHOLE DATA FROM THE BACA GEOTHERMAL FIELD

Topical Report

Prepared by
M. A. Grant
S. K. Garg

Date Published - May 1981

Prepared Under Subcontract to
WESTEC Services, Inc.

Prepared for
Public Service Company of New Mexico
Under Contract No. GEO-CLS-25

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ABSTRACT

Drilling records, downhole surveys and surface discharge measurements available from the first twenty wells drilled in the Baca Geothermal Field (Bond 1 through Baca 19) are analyzed to construct a preproduction model of the reservoir system. Because of convective effects in the wellbore, careful analysis of the measured pressure and temperature profiles is required to define those locations at which the measurements actually correspond to the reservoir formation conditions. The results of detailed well-by-well analyses are used to construct the initial pressure and temperature distributions in the portion of the reservoir corresponding to the Baca Geothermal Demonstration power Plant Project. This information together with the stratigraphic sequence and the zones of fracture permeability penetrated by the wells are presented on two vertical sections across the reservoir system. An initial two-phase region of the reservoir is also delineated; its extent is based on the measured CO_2 content of the Baca reservoir fluid as well as well data. The model of the initial state presented herein provides the framework needed for a re-examination of the available Baca pressure transient and well interference test measurements.

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SECTION 1: INTRODUCTION

1.1 Introduction

The Baca Geothermal Field is located in the Valles Caldera in north central New Mexico, 60 miles north of Albuquerque, and about 35 miles northwest of Santa Fe. The caldera is a prominent geologic structure in the Jemez mountains, a complex volcanic highland of Pliocene and Pleistocene age. The regional geology of the Valles Caldera is described by Hartz [1976]. The geothermal potential of the Valles Caldera came to be recognized in the early 1960's with the drilling of four exploratory wells (Bond 1 and Baca 1-3) in the Sulphur Creek area and confirmed in 1970 with the drilling of the discovery well (Baca 4) in the Redondo Creek area of the caldera. Union Oil Company leased approximately 100,000 acres of the Baca Ranch in April 1971 and began an active drilling program. By the end of 1976, Union had drilled two more wells in the Sulphur Creek area (Baca 7 and 8) and ten more wells in the Redondo Creek area (Baca 5-A, 6 and 9-16). Although these seventeen wells and other information indicate that the geothermal resource extends over a large part of the Valles Caldera, interest has centered on the Redondo Creek area.

The Public Service Company of New Mexico and the Union Geothermal Company of New Mexico, a subsidary of Union Oil Company of California, plan to install a 50 MWe geothermal power plant in the Redondo Creek area on Baca Location No. 1 within the Valles Caldera. This development was selected by the Department of Energy (DOE) as the first Geothermal Demonstration Power Plant (GDPP) Project. Under the arrangement DOE will contribute to the initial funding of the project in return for all technical, economic and institutional data resulting from it. PNM and Union, acting together as the Participant, will make the data available for interested parties through a Data Gathering, Evaluation and

Dissemination subcontractor. WESTEC Services, Inc. is the subcontractor selected by the Participant for this phase of the GDPP Project. Systems, Science and Software (S^3) is the member of the WESTEC team responsible for the geological, geophysical and reservoir engineering aspects of the subcontract.

This report summarizes the work done to date by S^3 to deduce the initial state of the Baca reservoir system from the available drilling records, downhole surveys, and surface discharge measurements. The drilling records provide essential information defining the stratigraphy of the reservoir system. The downhole surveys measure the properties -- pressure, temperature and in some cases the flow rate of the fluid occupying the wellbore. Because of convective flow within the wellbore, these properties are most often not the same as those existing in the reservoir prior to the drilling of the well and interpretation of these data is a major part of the work presented in this report. The surveys indicate the presence of isolated zones of fracture permeability in the reservoir formation rock. Discharge fluid enthalpy and chemical data indicate whether liquid or two-phase fluid enters the well, and cycling behavior in the discharge rate gives additional information about the distribution of fracture permeability down the wellbore.

1.2 Scope of the Report

Since initiation of the GDPP Project, seven additional wells (Baca 17-23) have been drilled to date in the Baca reservoir in the Redondo Creek area. This report is limited to wells drilled prior to 1980 (Bond 1 through Baca 19), however, since data from the four most recent wells are not yet available to S^3.

Section 2 describes techniques which can be used to determine the depths at which a well penetrates a permeable zone in a fractured geothermal reservoir system. Because of convective effects in the wellbore, careful analysis of the measured pressure and temperature profiles is required to define those locations at which the measurements actually correspond to the reservoir formation conditions. Section 3 presents the results of applying the interpretation techniques to the twenty wells in the Sulphur Creek (six wells) and Redondo Creek (fourteen wells) areas of the Valles Caldera for which information was available. A detailed discussion is given for each well. The results of these well-by-well analyses are used in Section 4 to construct the initial pressure and temperature distributions in the portion of the Baca reservoir system corresponding to the GDPP Project. This information together with the stratigraphic sequence and the zones of fracture permeability penetrated by the wells are presented on two vertical sections across the reservoir system. The initial two-phase region is also delineated; its extent is based on the measured CO_2 content of the Baca reservoir fluid as well as the pressure/temperature distributions constructed from the well data.

1.3 Summary and Conclusions

The reservoir pressures identified from an analysis of the Baca wells in the Redondo Creek area define a line of slope 0.348 psi/ft when plotted against elevations above sea level. This corresponds to a hydrostatic gradient at approximately 500°F. The uniform initial pressure gradient across the reservoir indicates communication over the time of the reservoir's natural flow but says nothing about permeability values being sufficiently large for practical fluid production. The initial temperature contours constructed from well analysis dome upward and an initial two-phase region is believed to be at the crest of the dome. There are two permeable zones across the portion of the Baca reservoir penetrated by the wells drilled to date. The deeper zone closely corresponds to the contact surface between the Bandelier Tuff and the underlying Andesite. The apparently more permeable shallower zone lies within the Bandelier Tuff. The fluid in the shallower zone is considerably cooler and lower in pressure than the fluid in the deeper zone.

contact may be a fault or slide afc.

Production from the wells feeding from the shallower zone (e.g., Baca 11 and Baca 15) would most probably decline more rapidly than from deeper feeding wells (e.g., Baca 13). The vertical variation in reservoir fluid (two-phase at the upper permeable zone, single-phase at the lower permeable zone) indicates that a realistic simulation of fluid production from the Baca system must have vertical structure in the reservoir model.

1.4 Recommendations for Future Study

Pressure transient and well interference tests have been performed on a number of the earlier Baca wells. These flow test data have been interpreted by Hartz [1976] to estimate the formation permeability of the Baca reservoir in the Redondo Creek area. His analysis, however, assumed the reservoir to contain single-phase liquid. The numerical simulations presented in two earlier S^3 topical reports have demonstrated that the existence of an initial two-phase region in the Baca reservoir (Garg and Pritchett [1980]) and the presence of CO_2 in the fluid (Pritchett, *et al.* [1981]) will produce important effects that must be considered in interpreting the well test data. The conceptual model of the initial state of the Baca reservoir system presented herein provides the framework needed for a re-examination of the available Baca pressure transient and well interference measurements.

SECTION 2: DETECTION OF PERMEABLE HORIZONS

2.1 Introduction

Convective effects in a wellbore penetrating a geothermal reservoir often totally dominate the measured pressure and temperature profiles. Interpretation of such data is treated by White, et al. [1975], Grant [1979a] and Stefansson and Steingrimsson [1980]. The heat and fluid mass transport mechanisms involved in the intersecting wellbore and fractured reservoir system are reviewed here in order to provide a framework for interpreting the available data from the Baca wells.

2.2 Summary

Because of convective flow within the wellbore (in some cases there may be flow into the well at some depth and out of the well into the formation at a different depth), measured temperature and pressure profiles are related to the formation conditions only at certain feed points. Comparison of successive temperature/pressure profiles measured during cold water injection and during the warmup period after injection provide the clearest way to determine an entry or loss of fluid from the well. Synthesis of this information, drilling information and geological correlations can define the depth(s) at which permeable zones are penetrated by the well.

2.3 Permeable Horizons

In a fractured reservoir such as Baca, a well does not penetrate a layer of uniform permeability. Rather the bulk of the reservoir permeability is in a fracture network, and the performance of the well depends largely upon whether it intersects one or more fractures, how large each intersected fracture is and how well it is connected to the rest of the network. The well is open to reservoir fluid only at the depth(s) where it intersects such a fracture, and for the balance of its depth the well penetrates rock that is hot but essentially impermeable. This situation is comparable to a well drilled into a thick sandstone, which has been fully cased, and perforated at a few unknown depths.

It is often difficult to locate the major entry that supplies fluid to a well with a long extent of open hole. Direct measurement by a flowmeter under discharge is usually not possible with available tools. There are, however, several indirect methods that can be used to deduce the location of fluid entries. These methods make use of the following information:

- drilling information - circulation losses
- geological correlations and petrology
- flow and temperature measurements during injection
- pressure and temperature measurements during warmup.

The latter two sets of measurements are taken when the well is either cold, or warming up. Measurements in the stable hot well usually offer little guidance.

If available, drilling information can be valuable. When drilling with mud or water, a zone of circulation loss should correspond to drilling through permeable rock. Similarly, when drilling with foam or air, permeable zones would be manifested by fluid gain. In both cases, care must be taken to relate the loss or gain of fluid to the difference between pressure in the hole and the reservoir pressure since this pressure difference may vary greatly with depth. If downhole measurements imply permeability at a particular depth, and a loss or entry was encountered nearby during drilling, it would normally be assumed that the drilling information defines the permeable depth more accurately. If there are multiple losses or entries during drilling, one needs the later downhole information to define the dominant entry (or entries).

Geological correlations can be useful in the developmental stages of a field. It may be possible to establish that permeability is associated with a stratum, with a particular formation contact, or with faulting. However, some wells must first be drilled to establish such a correlation. The hydrothermal alteration of cores or cuttings can be a reliable guide to whether the sample has been exposed to a vigorous flow of hydrothermal fluid, and hence to the local permeability - now or at some time in the past. Alteration can also indicate the nature of the reservoir fluid - liquid, boiling, or vapor-dominated.

Measurements during and after injection provide the clearest way to determine an entry or loss of fluid from the well. Figure 2.1 shows three possible types of temperature profiles that may be observed while cold water is being injected into a geothermal well.

The well in Figure 2.1 has two permeable zones, marked by crosses on the depth axis. Profile 1 is the simplest. Water enters at the wellhead (Z=0). The measured temperature increases very slowly to depth Z_2, then it increases rapidly. The rapid temperature increase below Z_2 indicates that little or no water penetrates below Z_2; the depth Z_2 is the major zone of fluid loss.

Profile 2 shows a break in gradient at depth Z_1, followed by a sharp increase in gradient at Z_2. This indicates some fluid loss at depth Z_1, and loss of all or nearly all of the balance of the injected fluid by depth Z_2. This inference follows from a

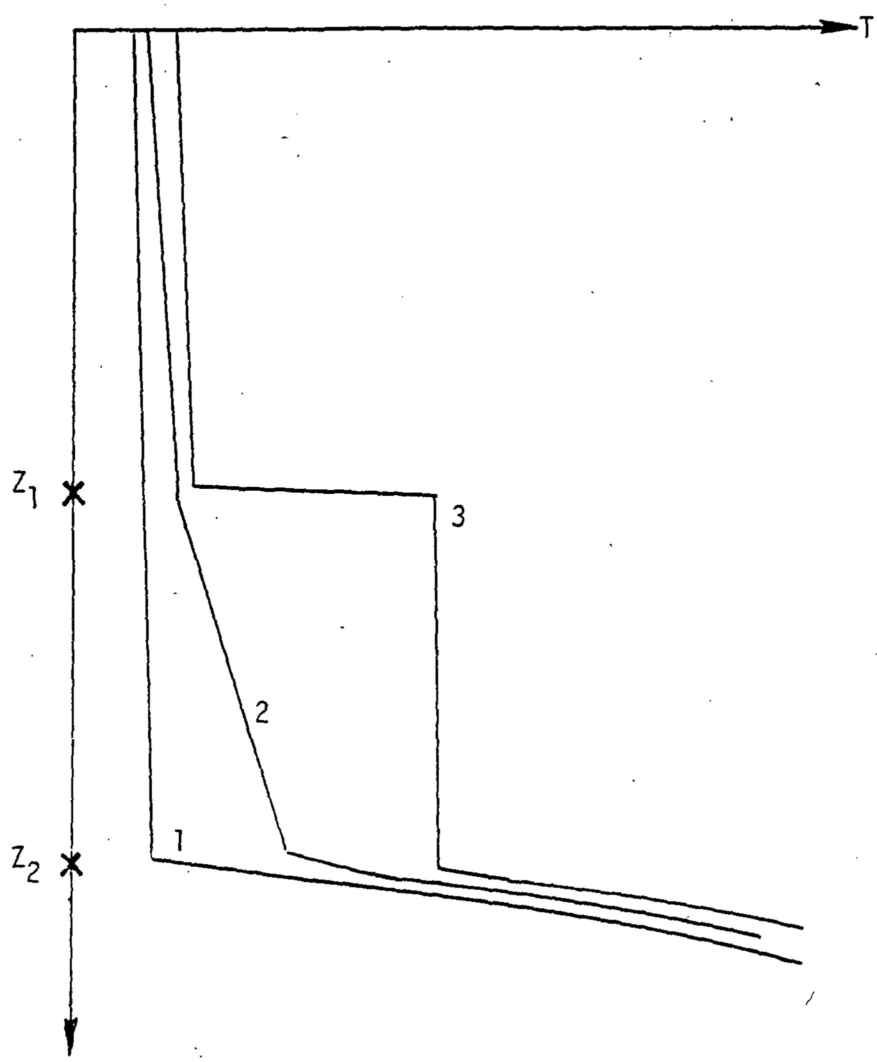

Figure 2.1. Temperature Profiles Under Cold-Water Injection.

heat balance on the water descending the wellbore (Ramey [1962]). Except at zones of permeability, the well gains heat by conduction from the surrounding formation. Figure 2.2 shows a simple model for this conductive heat gain. W is the mass flow rate down the well, $T_w(Z)$ is the temperature in the well, and $T_r(Z)$ is the formation temperature. The conduction of heat into the well, caused by the temperature difference $T_r - T_w$, heats the descending water:

$$W\, C_w \frac{d\,T_w}{dZ} = \frac{4U}{d}\,(T_r - T_w) \quad ,$$

where

C_w = specific heat of the fluid
d = wellbore diameter
U = overall heat transfer coefficient.

The temperature gradient dT_w/dZ is inversely proportional to the flow rate W. Therefore, the changes in gradient in profile 2 of Figure 2.1 - an increase in dT_w/dZ - indicate a decrease in W, and hence, water loss from the well. In many cases of geothermal interest, flow rates are so large (compared to petroleum wells) that dT_w/dZ is small, or even, within measurement error, zero. Profile 1 (an "isothermal" profile) indicates essentially no change in T_w between wellhead and datum Z_2.

Profile 3 shows a jump in temperature at Z_1. This indicates fluid inflow at Z_1. Hot fluid enters the well at Z_1, mixes with the cold water from wellhead, and the entire flow is injected at Z_2. If the enthalpy/temperature of the inflow at Z_1 can be estimated, the amount of the inflow can be calculated by a heat balance. Assuming that T_+ is the temperature in the well above Z_1, T_- is the temperature below Z_1, and H_1 is the inflow enthalpy, the inflow W_1 is given by

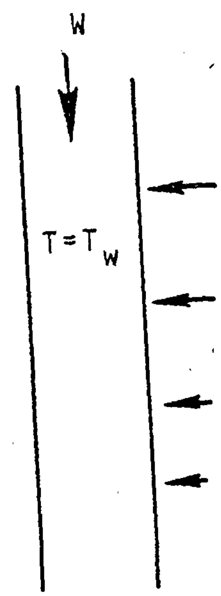

Figure 2.2. Heat Balance in an Injection Well.

$$WH_w(T_+) + W_1H_1 = (W + W_1)\, H_w(T_-)$$

With a reliable spinner or other downhole flowmeter, the flow rate in the well can be measured directly. Although experience in New Zealand with a Kuster Spinner has been disappointing, more recent use of an accurate surface-recording spinner-temperature tool has confirmed the validity of these inferences from temperature surveys (Syms, et al. [1980]).

Regardless of how the inflows to or outflows from the well are measured, it is necessary to compare the pressure profile in the well with the pressure distribution in the reservoir to quantitatively compare the fluid loss or gain at the two depths. Figure 2.3 shows two possible pressure profiles. Profile 1 shows much larger difference between wellbore and formation pressures at Z_2 than at Z_1 so that a smaller fluid loss at Z_1 need not imply less permeability there than at Z_2. Profile 2 indicates the pressure profile corresponding to temperature profile 3 in Figure 2.1, i.e., fluid enters the well at Z_1 and is injected into the formation at Z_2.

The behavior of the well as it warms up after cold water injection provides additional information regarding permeability. Indications of permeability appear both in pressure and temperature surveys.

In temperature profiles, permeability can be indicated by a marked feature (in successive surveys) such as:

- cooling by injection
- rapid warming
- interzonal flow.

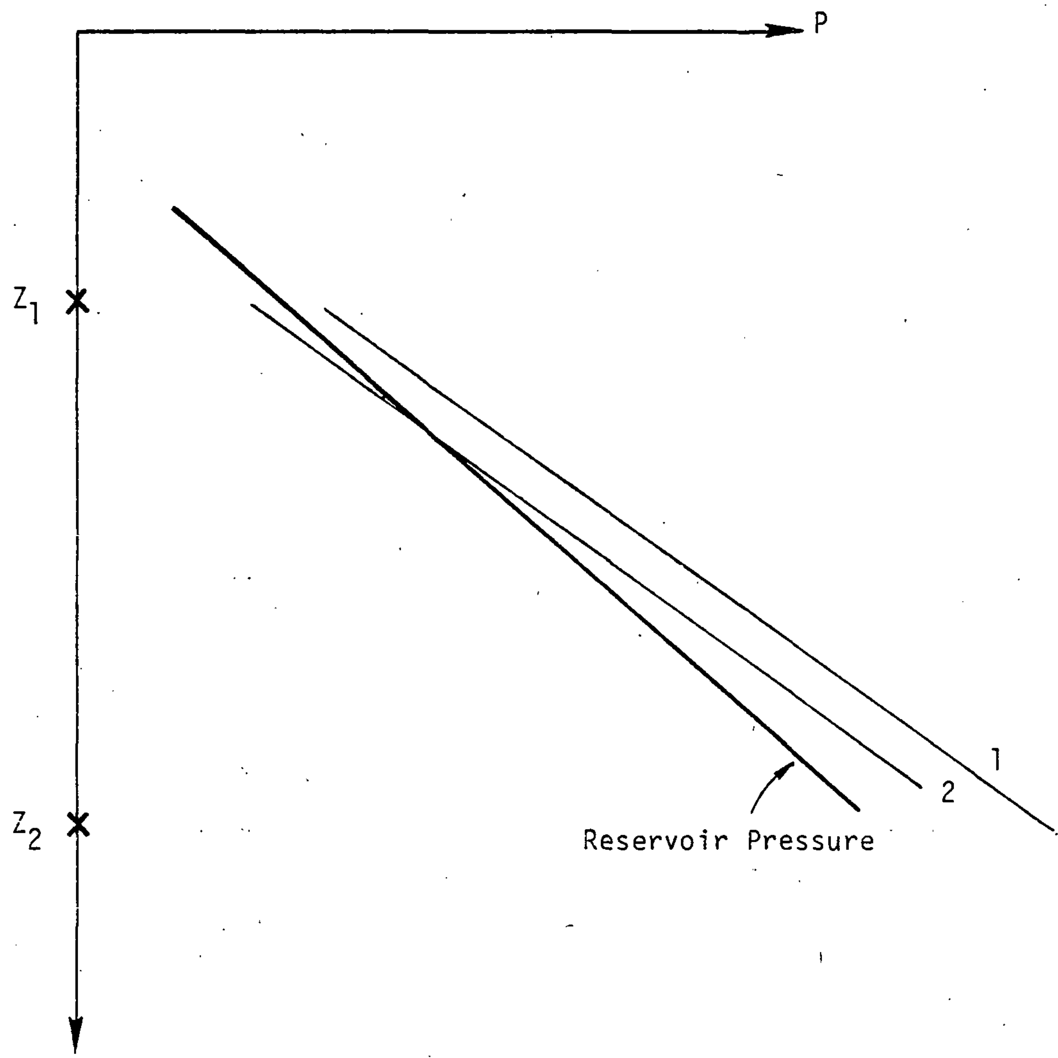

Figure 2.3. Pressure Profiles Under Injection.

The permeable zone which has accepted water during injection may appear as a persistent cold feature as the well warms. If the injected cold water does not move to other parts of the reservoir, it will take longer to heat this portion of the well than the impermeable sections of the well that have not accepted fluid. Alternatively, the permeable zone may permit rapid circulation of the injected water away from the well, and there appears a marked peak in the heating surveys. Finally, the disturbed pressures may initiate a flow between two permeable zones of the well. Such a transient flow during warmup is manifested by an isothermal temperature profile and indicates permeability at both its end points.

2.4 Pressure Profiles

The pressure profiles can provide information by showing a "pivot" as the well warms. Figure 2.4 illustrates the mechanism. The well in Figure 2.4 has a single entry at Z_1. Profile 1 is during cold water injection. As the well warms, two physical mechanisms affect the downhole pressures. There is the transient decay of the pressure buildup caused by injection, and the change in gradient caused by the warming of the water column in the well. The transient decay of pressure will generally be complete before much warming has occurred. This produces profile 2 - with the cold water pressure gradient, but where the pressure at Z_1 has reached equilibrium with reservoir pressure. As the well contacts the reservoir only at its permeable point, only here does it equilibrate with the reservoir. The pressures measured at other depths in the well merely reflect the weight of the fluid column present (or flowing) in the well. As the well warms up, the water column lightens to produce profiles 3 and 4. The successive profiles pivot about the reservoir pressure at depth Z_1.

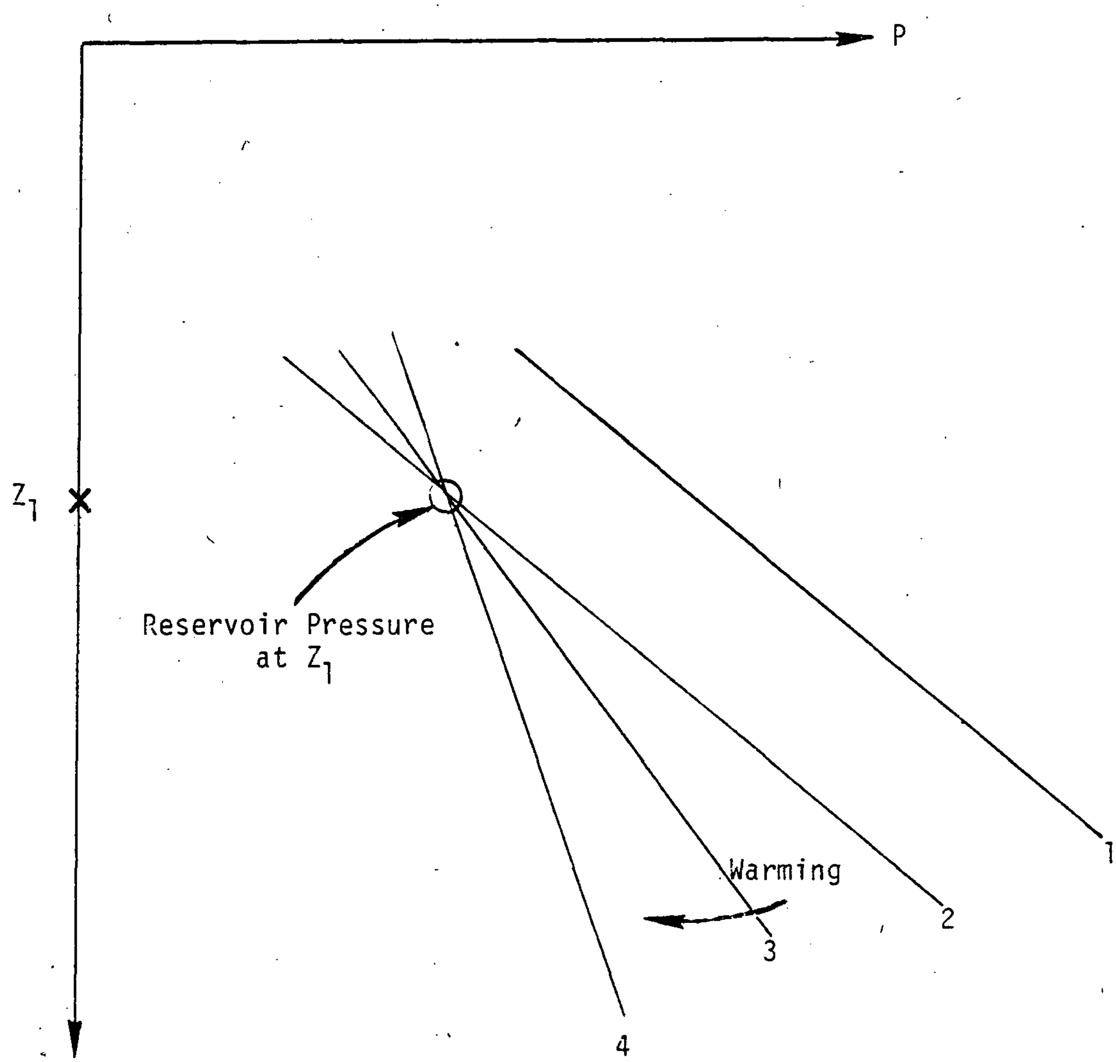

Figure 2.4. Pressure Pivot During Warmup (Differences in Gradient Exaggerated).

In the preceding discussion, it was assumed that the pressure transient caused by injection decays rather rapidly. For injection into a homogeneous single-phase aquifer, the time required for pressure transient to decay is a multiple of the injection time. In practice the pressure decay is often much faster. An example of this is shown by the measurements in Baca well B-18 which will be discussed later in this report. In general, the pressure pivot works best in wells of good permeability, where the pressure transients are small. If transient effects are present, the pivot is displaced above the feed zone. As a check on the pivot, it should be defined by the intersection of more than two pressure surveys, and preferably with as wide a range of temperatures as possible. The large temperature difference means more contrast in pressure gradient.

If there are two significant permeable zones, the pressure pivot usually appears between them at a point weighted by the permeability ratio of the two zones. In this case the pressure at the pivot is a linear interpolation between the reservoir pressures at the two zones; and probably corresponds closely to reservoir pressure at the depth of the pivot.

Having identified the wells' permeable depths, measured pressures at these different depths in the various wells can be used to construct a reservoir pressure profile. Reservoir temperatures can also be determined from downhole measurements which are unaffected by convection or interzonal flow in the well.

SECTION 3: ANALYSIS FOR INDIVIDUAL WELLS

3.1 Introduction

This section presents the analyses of drilling information and pressure/temperature surveys for each well drilled at Baca for which information is available (Bond 1 and B-1 through B-19). In the following discussion, depths are given either in terms of measured depth (feet) from the wellhead along the wellbore, or in terms of elevation (feet) above sea level. Thus, 3,000 ASL denotes an elevation of 3,000 ft above sea level whereas 3,000 ft denotes measured depth along the wellbore. Since many of the Baca wells are deviated, the measured depths along the wellbore do not necessarily indicate vertical depths from the surface. To derive true vertical depths from the measured depths along the wellbore (e.g., elevation above sea level), it is thus necessary to correct for well deviation.

3.2 Summary

Detailed analyses of the individual wells in the Sulphur Creek and Redondo Creek areas identify the reservoir pressures and reservoir temperatures at major feed points in the wells. Locations of the single-phase and two-phase regions within the reservoir are also identified.

3.3 Well Bond No. 1 (Sulphur Creek Area)

Ground Surface Elevation: 8697 ASL
Total Depth of Well: 3675 ft
Depth of 9-5/8" Casing: 1217 ft
Open Intervals: below 1217 ft
Deviation Data: unavailable

The well is abandoned, and no pressure/temperature surveys are available.

3.4 Well Baca No. 1 (Sulphur Creek Area)

Ground Surface Elevation: 8350 ASL
Total Depth of Well: 2560 ft
Depth of 13-3/8" Casing: 461 ft
Open Intervals: below 461 ft
Deviation Data: unavailable

The well is plugged and abandoned. No pressure/temperature surveys are available.

3.5 Well Baca No. 2 (Sulphur Creek Area)

Ground Surface Elevation: 8500 ASL
Total Depth of Well: 5658 ft
Depth of 9-5/8" Casing: 3445 ft
Open Intervals:
1. Various perforated intervals from 1300 to 1460 ft, 1750 to 2300 ft, and 2400 to 3100 ft
2. 7 inch slotted liner from 3397 to 4726 ft
3. Open hole below 4726 ft

Deviation Data: unavailable

The well is plugged and abandoned, and no downhole pressure/temperature surveys are available.

3.6 Well Baca No. 3 (Sulphur Creek Area)

Ground Surface Elevation: 8350 ASL
Total Depth of Well: 2200 ft (estimated)
Depth of 9-5/8" Casing: 1179 ft
Open Intervals:
1. Blank and perforated 7 inch liner from 1000 to 1983 ft
2. Open hole below 1983 ft

Deviation Data: unavailable

The well is plugged and abandoned, and no downhole surveys are available.

3.7 Well Baca No. 4 (Redondo Creek Area)

Ground Surface Elevation: 9318 ASL
Zero Point for Downhole Surveys: 9332 ASL
Drilling Information:
1. (9/11/70 - 10/12/70) drilled to a depth of 5048 ft (4301 ASL)
2. (6/07/73 - 6/28/73) deepened to a depth of 6378 ft (2987 ASL)

Casing Data:

1. Depth of 9-5/8" casing: 3182 ft (6145 ASL)
2. 7 inch slotted liner from 3031 to 6276 ft (installed 6/07/73 - 6/28/73)
3. 7 inch blank liner from 0 to 2985 ft (installed 9/20/76 - 10/21/76)

Formations Encountered During Drilling:

1. Caldera Fill: 0 - 200 ft (9318 - 9119 ASL)
2. Bandelier Tuff: 200 - 5980 ft (9119 - 3380 ASL)
3. Paliza Canyon Andesite: 5980 - 6378 ft (3380 - 2987 ASL)

3.7.1 Analysis

Extensive observations during drilling are reported for B-4 (Hartz [1976]; Dondanville [1971]). Vapor-dominated zones were encountered at 2625 - 3177 ft, and 3468 - 4991 ft. It is also stated that water-bearing zones were reached at 5000 ft. The contact between vapor-dominated and water-bearing zones is confirmed by a change in hydrothermal alteration. When drilling over the range 2725 - 3117 ft the stable shutin wellhead pressure was 60 - 70 psig. Beneath this depth the shutin wellhead pressure rose with increasing depth. A pressure of 500 plus psig was attributed to a zone at 3468 ft.

The downhole pressure/temperature surveys in the completed well, however, (Figures 3.1 and 3.2) show no evidence of a steam zone. Were a vapor-dominated zone present at, for example, a pressure of 500 psig, the well would develop a stable wellhead pressure of 500 psig (Grant [1979a]); it does not do so. It is notable that the pressure of 500 psig at 3468 ft lies near the trend of Baca reservoir pressures, and of the pressures measured in the completed well.

The shallow vapor zone (2625 - 3177 ft) temperature was given as 310 - 320°F. The temperature profiles measured in the completed well certainly do not show this, casting doubt on the temperatures

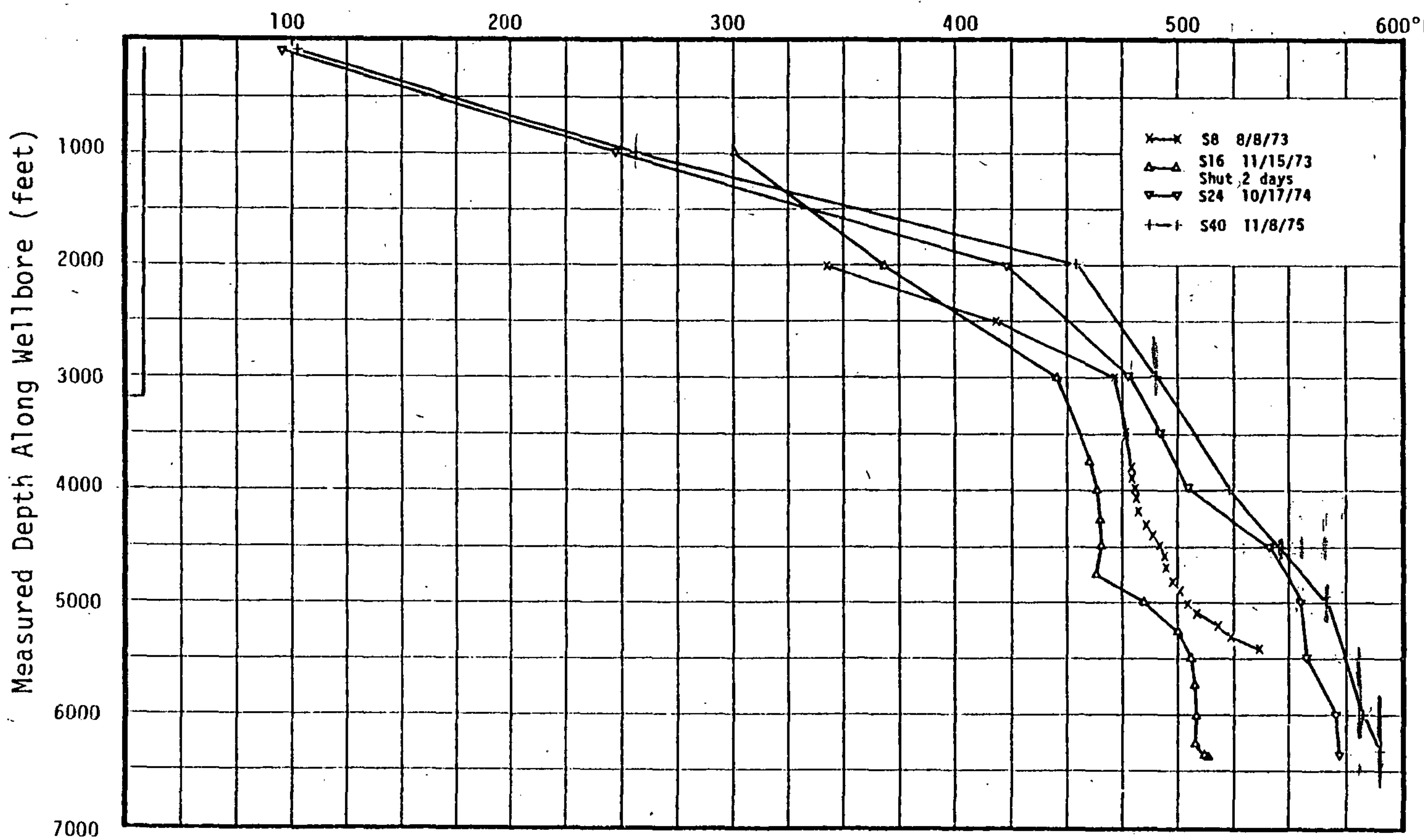

Figure 3.1. B-4 Temperatures

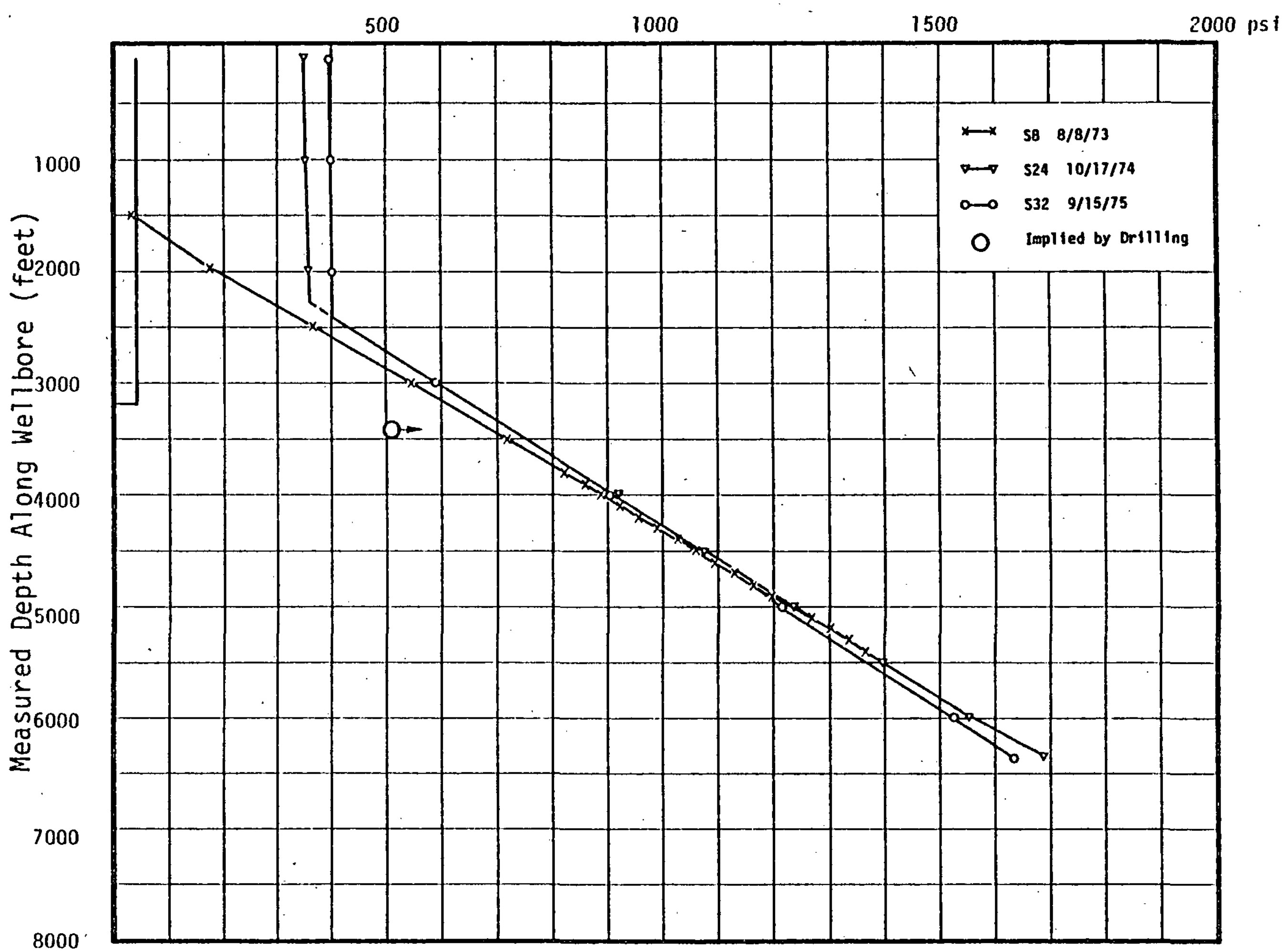

Figure 3.2. B-4 Pressures

in the cased sections of the well as an indication of the reservoir temperature; and hence on any inference of a cap rock based on the temperature profiles.

Downhole pressures appear to pivot at approximately 4500 - 5000 ft indicating that the dominant permeability is here. This depth is also the location of a marked thermal feature after discharge (S16-T); there is also a persistent dip in the generally smooth temperature profile at this depth. This indicates that the reservoir temperatures around this depth are probably significantly below the temperatures measured in downhole surveys (S24-T, S40-T).

The measured temperatures and pressures in B-4 are very close to saturation conditions for water. This suggests that the temperature (or pressure) profile in B-4 is a "boiling point profile" (Grant, 1979a,b). Such a profile is caused by boiling fluid entering and flowing up the well, and the measured profile reflects the temperature of the column of boiling water and not the reservoir temperature. In B-4, the cold spot near 5000 ft apparently manages to cool the upflow as it passes that depth. The pressure data indicates that the zone below 3177 ft is liquid-dominated, which could be either liquid or two-phase.

The above interpretation implies that there is two-phase fluid in the reservoir near bottom hole since this fluid supplies the upflow of the boiling-point profile. There is also two-phase fluid near 3500 ft (Dondanville, 1971). For a region near 5000 ft liquid water exists at temperatures below those of the stable temperature profile in the well.

3.7.2 Summary

Primary permeability at 5000 ft (~4349 ASL) or below. Two-phase fluid from 5500 ft (~ 3855 ASL) to bottom hole (~ 2987 ASL) and near 3500 ft (~ 5831 ASL). Liquid near 5000 ft (~ 4349

ASL). Reservoir temperature from 5500 ft (~ 3855 ASL) to bottom hole (~ 2987 ASL) given by S40. Reservoir temperature at 5000 ft (~ 4349 ASL) below S40. Reservoir pressure at 4500 ft (~ 4843 ASL) 1070 psig.

3.8 Well Baca No. 5 (Redondo Creek Area)

Ground Surface Elevation: 9302 ASL
Date of Drilling: 7/18/71 - 8/11/71
Total Depth of Well: 2878 ft
Deviation Data: unavailable

The well is plugged and abandoned. No downhole surveys are available.

3.9 Well Baca No. 5A (Redondo Creek Area)

Ground Surface Elevation: 9302 ASL
Date of Drilling: 8/13/71 - 9/20/71
Total Depth of Well: 6973 ft (2339 ASL)
Depth of 9-5/8" Casing: 4400 ft (4908 ASL)
Open Intervals: 8.75 in open hole below 4400 ft (4908 ASL)
Formations Encountered During Drilling:

1. Caldera Fill: 0 - 440 ft (9302 - 8863 ASL)
2. Bandelier Tuff: 440 - 6600 ft (8863 - 2711 ASL)
3. Paliza Canyon Andesite: 6600 - 6973 ft (2711 - 2339 ASL)

3.9.1 Analysis

Temperature and pressure profiles are shown in Figures 3.3 and 3.4 respectively. S8 shows the stable temperature profile in the well. S13 gives the temperature profile under injection; this temperature profile indicates (by the lack of an increase in gradient) that water is being lost near the bottom of the survey at a depth of 6400 ft. Temperature Survey S13-T, however, shows a small gradient in the depth interval 3500 ft - 4500 ft where the stable temperature (Survey S8) is low. Survey S11 taken 16 days after cold-water injection is interesting. It shows an isothermal profile between 3500 ft and 6250 ft at 300°F. Beneath 6250 ft

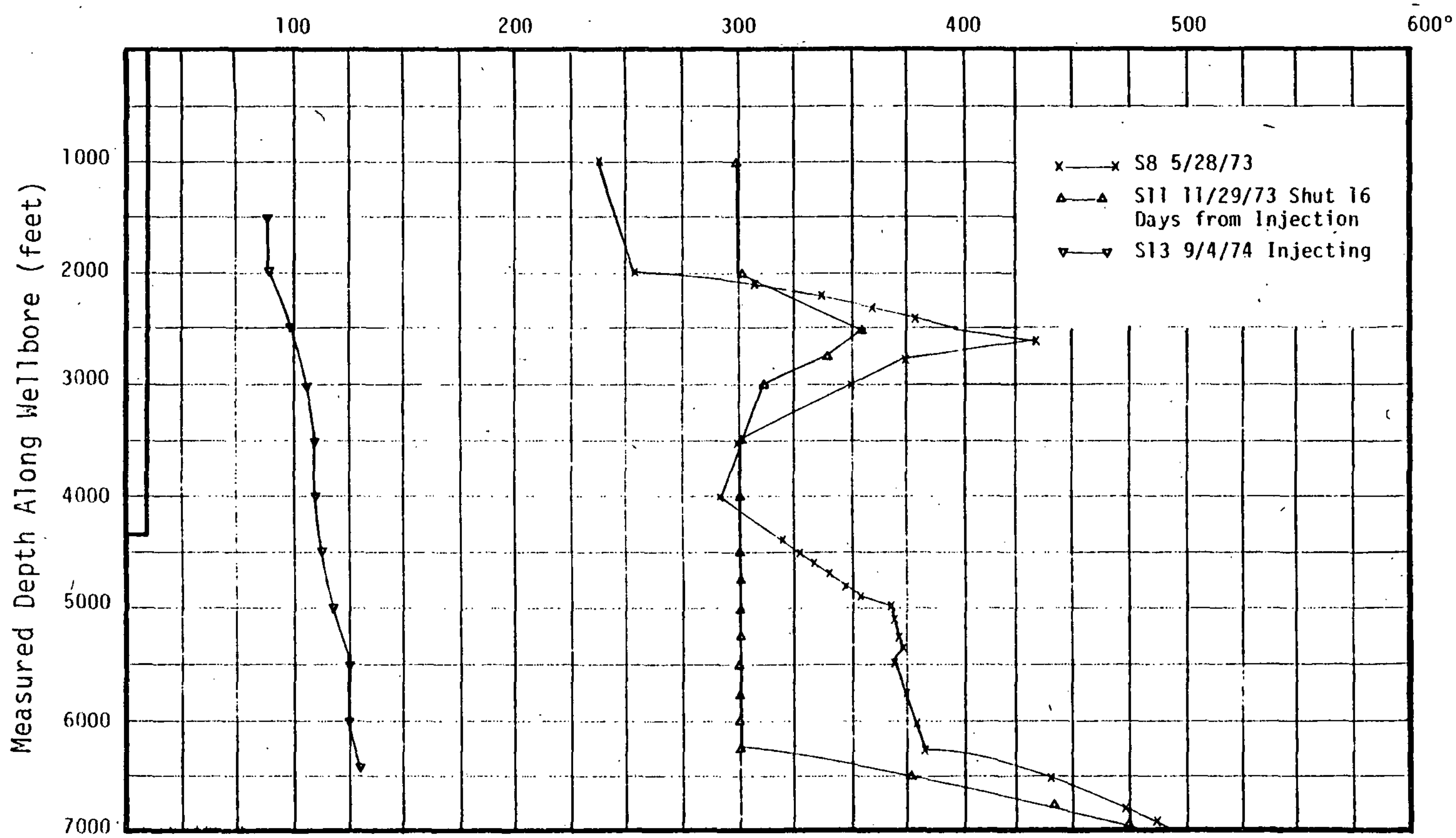

Figure 3.3. B-5A Temperatures

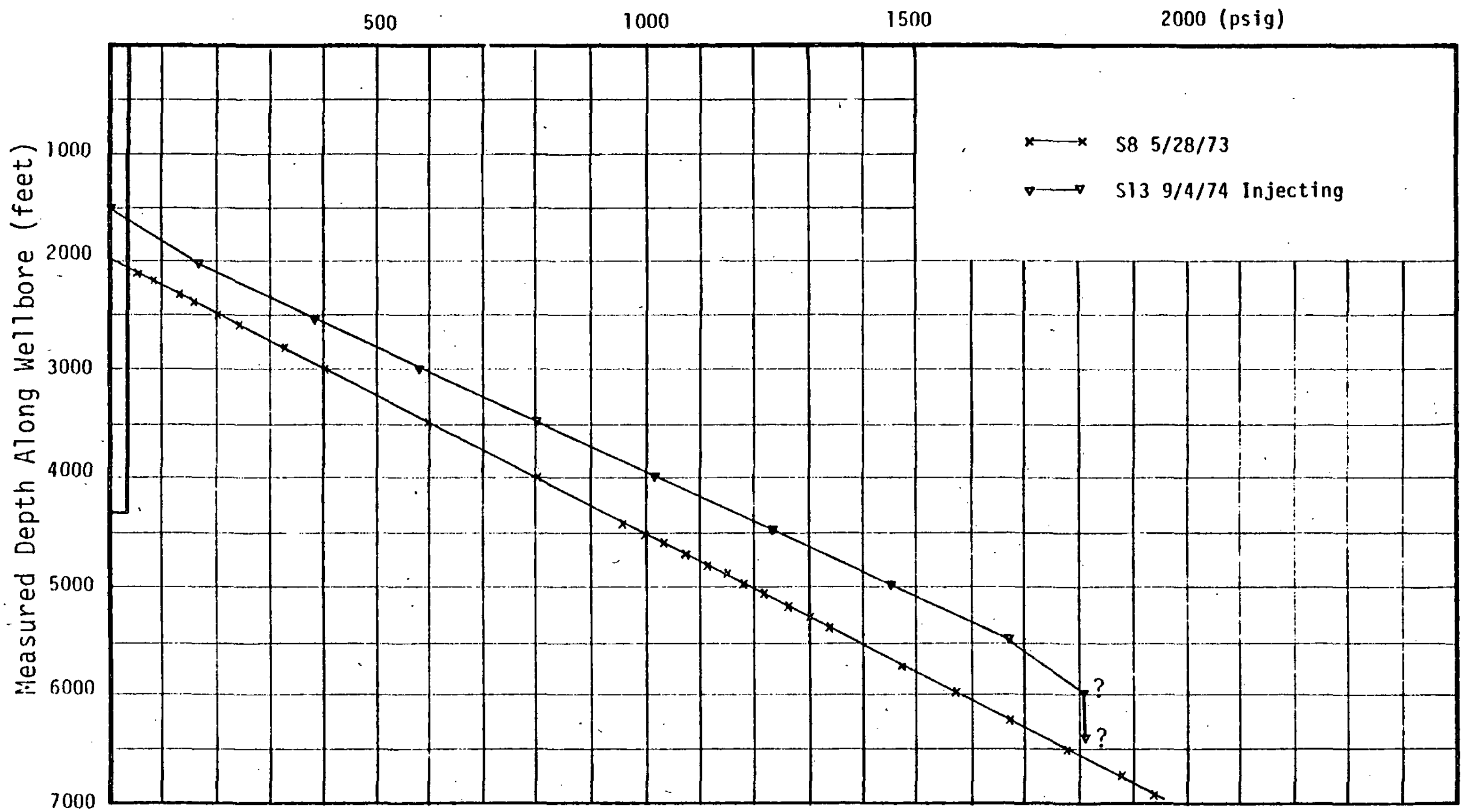

Figure 3.4. B-5A Pressures

temperatures are near stable values. The injection temperature is not stated, but it is unlikely that 300°F water was used. We, therefore, believe that this isothermal segment indicates a flow between 3500 to 6250 ft and hence permeability at both depths. (It is thus likely that there is a break in 9-5/8" casing at 3500 ft.) Presumably the water flowing is a backflow of a mixture of injected water and reservoir water. Survey S13 indicates that the dominant permeability is at 6250 ft.

With permeability at 3500 ft and 6250 ft and interzonal flow after injection, the stable temperatures over this interval as inferred from S8, are suspect. The sharp temperature rise beneath 6250 ft most likely reflects reservoir temperatures. There is a possibility that a small downflow is present in the stable state of the well -- water entering the well near 3500 ft, flowing down and being conductively heated until injected at 6250 ft. As there is a temperature minimum at 4000 ft it appears that the hypothesized downflow enters the well at this depth.

3.9.2 Summary

Primary permeability at 6250 ft (~ 3061 ASL), secondary permeability at 3500 ft (~ 5807 ASL). Reservoir pressure at 6250 ft (~ 3061 ASL) is 1685 psig. Reservoir temperature in the interval 2000 - 3500 ft (~ 7305 - ~ 5807 ASL) and beneath 6500 ft (~ 2811 ASL), given by S8. Reservoir temperatures at 3500 - 6500 ft (~ 5807 - ~ 2811 ASL) probably unknown. Reservoir fluid compressed liquid (because of low temperatures).

3.10 Well Baca No. 6 (Redondo Creek Area)

Ground Surface Elevation: 8726 ASL
Zero Point for Downhole Surveys: 8740 ASL
Drilling Information:

1. (7/08/72 - 7/23/72) drilled to a depth of 3715 ft (5044 ASL)
2. (3/01/75 - 4/14/75) well deepened to 4810 ft (3978 ASL)

Casing Data:

1. (7/08/72 - 7/23/72) bottom of 9-5/8" casing at 795 ft (7933 ASL); 7" liner over the interval 692 - 3700 ft (8036 - 5058 ASL), perforated below 2633 ft (6100 ASL)
2. (3/01/75 - 4/14/75) pulled 7" slotted liner; installed 7" liner from 0 to 2585 ft (8726 - 6147 ASL); 8.75 inch open hole below 2585 ft (6147 ASL)

Formations Encountered During Drilling:

1. Caldera Fill: 0 - 500 ft (8726 - 8227 ASL)
2. Bandelier Tuff: 500 - approximately 4767 ft (8227 - 4033 ASL)
3. Andesite: 4767 - 4810 ft (4033 - 3978 ASL)

3.10.1 Analysis

Downhole temperature and pressure surveys for B-6 are shown in Figures 3.5 and 3.6 respectively. B-6 has exhibited two distinct stable downhole pressure profiles. Early measurements (1972-73) repeatedly show the same profile: a hydrostatic gradient beneath about 2700 ft a gradient intermediate between that of water and steam in the depth range of 1000 ft - 2700 ft, and above approximately 1000 ft a column of steam or gas. An increase in pressure gradient above 1200 ft is repeatedly measured. After some fluid injection in 1974, the intermediate gradient has disappeared, and temperatures are lower. The well was then deepened without much change in downhole state. Well discharge, however, improved on deepening of the well in 1975.

Discharge enthalpy before deepening the well corresponded to water at 524 - 536°F. The intermediate density fluid in the well in 1972 - 73 indicates some circulation of boiling fluid in the well. This boiling fluid could be caused by an inflow of boiling fluid near 2700 ft, ascending and being injected higher; or by an inflow of liquid deeper in the well, ascending and boiling in the well. Since the temperature is not constant in the lower part of the well, the second possibility is excluded; and it is concluded that B-6 penetrated a two-phase fluid layer near 2700 ft. The low discharge

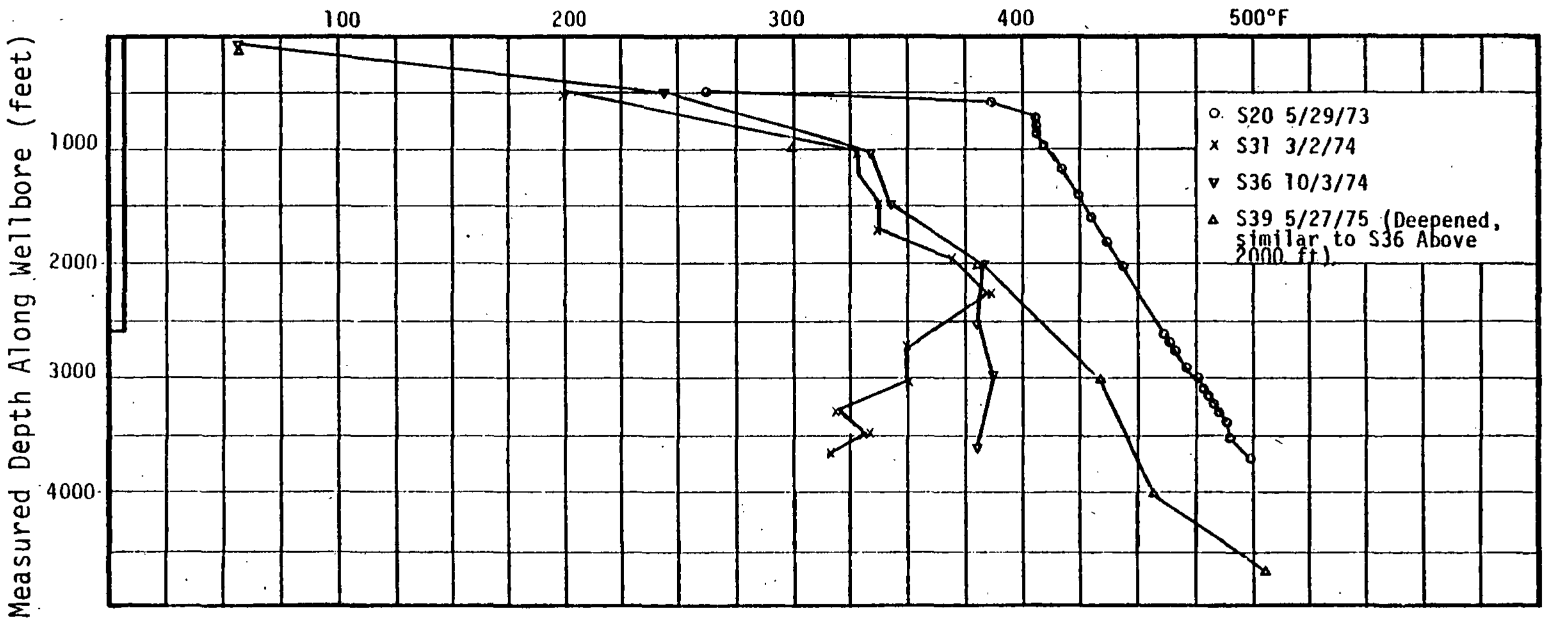

Figure 3.5. B-6 Temperatures

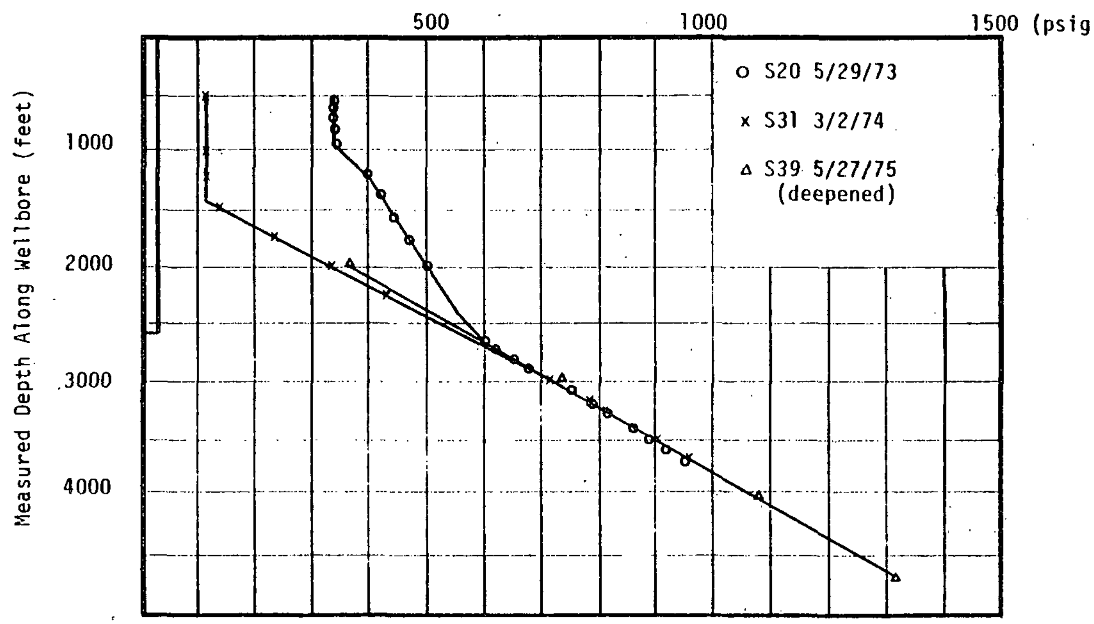

Figure 3.6. B-6 Pressures

enthalpy, however, indicates that this zone did not provide the bulk of the discharge. The survey S31 (3/2/74), presumably after injection, indicates fluid loss deeper in the well (possibly around 3700 ft).

The boiling fluid (in the depth range 1000 - 2700 ft) disappears from the well in 1974, and does not return. This is of considerable interest, as it marks the first (and apparently to date, the only) permanent change in Baca induced by exploitation. The injection temperatures (Survey S31) and discharge enthalpy indicate that there was only minor permeability in this two-phase zone. Perhaps there was only a comparatively small region of permeable rock, which was depleted of fluid by discharge. Early measurements at Wairakei (New Zealand) sometimes indicated the presence of fluids of enthalpy above the general reservoir trend. Such anomalous pockets tended to deplete rapidly, and the affected wells began exhibiting behavior similar to their neighbors.

3.10.2 Summary

Two-phase fluid originally present around 2700 ft (6035 ASL) possibly depleted by discharge. Original reservoir temperature at 2700 ft (6035 ASL), 475°F. Probably liquid water found on deepening. Major permeability around 3700 ft (~ 5058 ASL) and 4750 ft (~ 4033 ASL). The latter permeable horizon is indicated by a break in drilling at this depth. Reservoir pressure at 3700 ft (~ 5058 ASL) is 950 psi.

3.11 Well Baca No. 7 (Sulphur Creek Area)

Ground Surface Elevation: 8724 ASL
Zero Point for Downhole Survery: 8732 ASL
Date Completed: 8/5/72
Total Depth of Well: 5532 ft
Deviation Data: unavailable

Casing Data:
1. Bottom of 9-5/8" casing: 2908 ft
2. 7" liner from 2697 to 5515 ft; liner slotted from 3202 to 5512 ft

Formation Encountered During Drilling:
1. Valles Rhyolite: 0 - 1400 ft
2. Caldera Fill: 1400 - 2300 ft
3. Bandelier Tuff: 2300 - 3300 ft
4. Tertiary Sediments: 3300 - 3960 ft
5. Permian Redbeds: 3960 - 4840 ft
6. Pennsylvanian Limestones: 4840 - 5460 ft
7. Granite: below 5460 ft

Only one pressure/temperature survey is available for this well (see Figure 3.7). Baca reservoir pressure, as deduced from Redondo Creek Wells, is also shown in Figure 3.7. Both the downhole pressure and temperature surveys show a change in gradient at approximately 4500 ft; since the fluid in the well is liquid, this change in pressure gradient is most easily explained by a measurement error. Above 4000 ft, the measured pressure in B-7 is similar to the Baca reservoir pressure.

3.12 Well Baca No. 8 (Sulphur Creek Area)

Ground Surface Elevation: 8631 ASL
Zero Point for Downhole Surveys: 8637 ± 1 ASL
Date Completed: 9/13/72
Total Depth of Well: 4384 ft
Deviation Data: Unavailable
Casing Data:
1. Bottom of 9-5/8" casing: 2281 ft
2. 2-3/8" tubing: 0 - 4225 ft

Formations Encountered During Drilling:
1. Caldera Fill: 0 - 580 ft
2. Bandelier Tuff: 580 - 3100 ft
3. Tertiary Sediments: 3100 - 4000 ft
4. Permian Redbeds: 4000 - 4384 ft

The available pressure/temperature surveys for B-8 are shown in Figure 3.8. Temperature survey S3-T in B-8 is a nice boiling-point profile, indicating that boiling water is entering and flowing up the well. It, therefore, appears that B-8 penetrates two-phase conditions toward bottomhole, with no information available about conditions elsewhere.

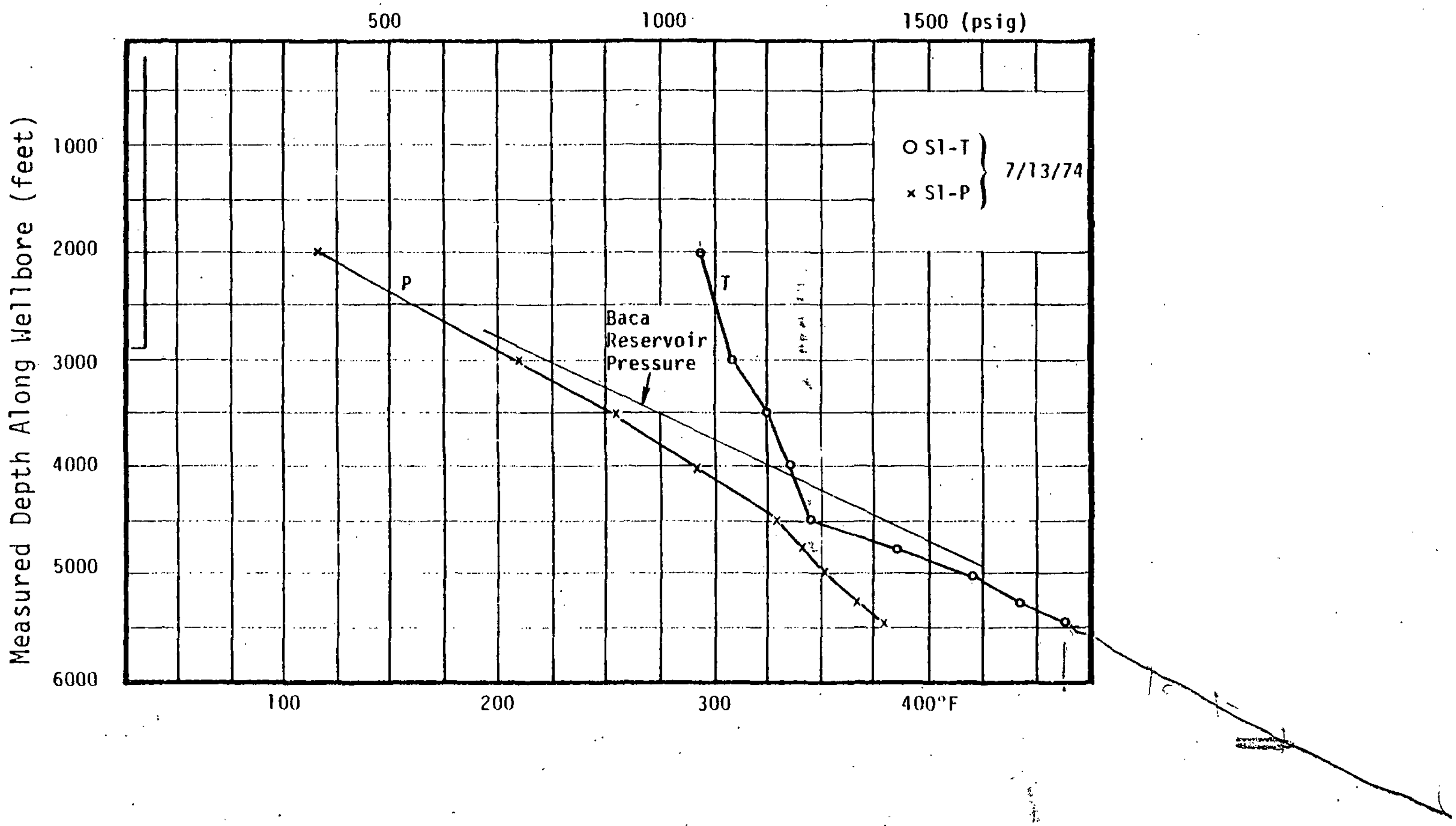

Figure 3.7. B-7 Pressure and Temperature

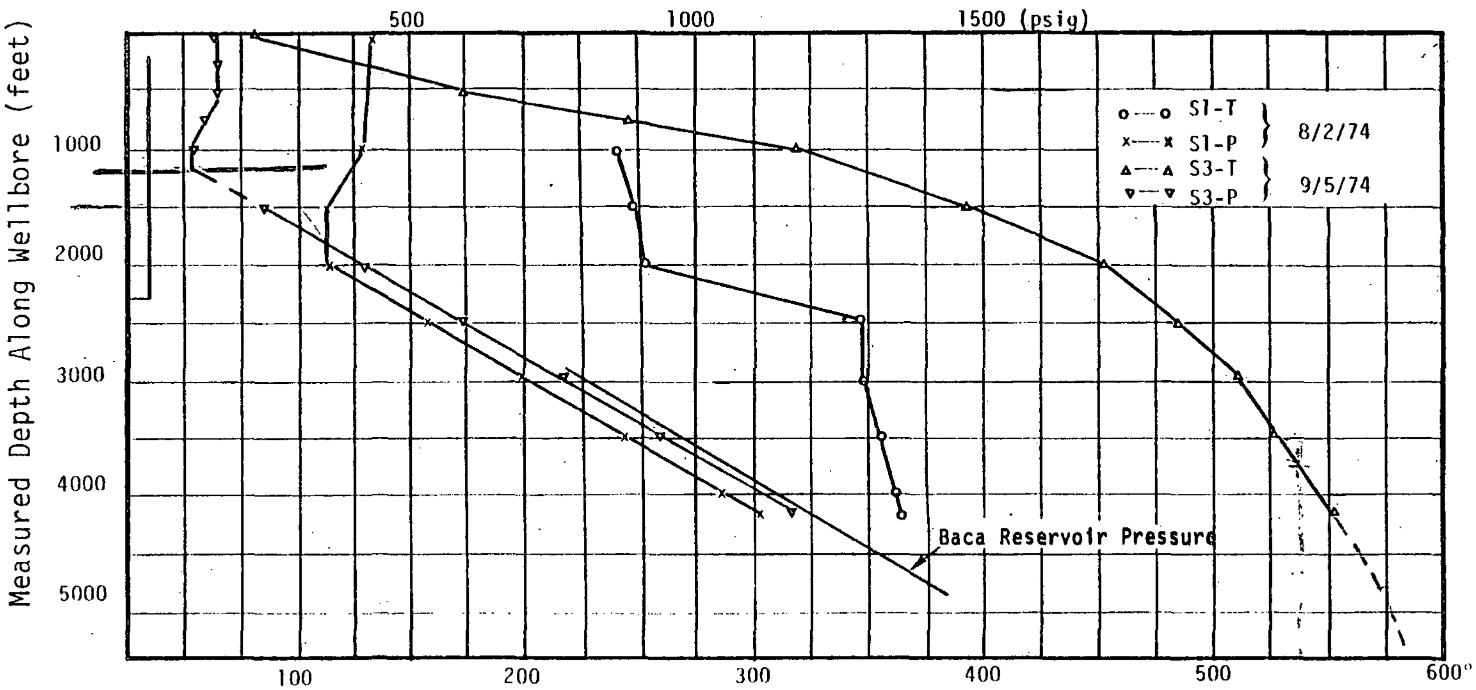

Figure 3.8. B-8 Pressure and Temperature.

Baca reservoir pressure is also plotted on Figure 3.8. It is similar to the downhole pressures in B-8 confirming that this well penetrates the same system as do the Redondo Creek Wells.

3.13 Well Baca No. 9 (Redondo Creek Area)

Ground Level Elevation: 8605 ASL
Drilling Data:
1. (9/15/73 - 10/13/73) drilled to a depth of 3518 ft
2. (10/13/73 - 11/21/73) sidetracked well at 2433 ft, drilled to a depth of 5303 ft

Casing Data:
1. Bottom of 9-5/8" casing: 3599 ft
2. 8.75" open hole below 3599 ft

Formation Encountered During Drilling:
1. Gravel: 0 - 80 ft
2. Bandelier Tuff: 80 - 5303 ft

Deviation Data: unavailable

The well was plugged and abandoned due to inability to recover 250 ft of stuck pipe and the extremely hazardous conditions created by worn and damaged casing. No downhole pressure/temperature surveys are available.

3.14 Well Baca No. 10 (Redondo Creek Area)

Ground Level Elevation: 8733 ASL
Zero Point for Downhole Surveys: 8744 ASL
Total Depth of Well: 6001 ft (2755 ASL)
Casing Data:
1. (7/05/73 - 9/18/73) bottom of 9-5/8" casing set at 4418 ft (4334 ASL); 7" slotted liner (slots from 4406 - 5595 ft and 5761 - 5986 ft) hung from 4278 to 6000 ft.
2. (8/75) casing perforated over the interval 3075 to 4195 ft.

Formations Encountered During Drilling:
1. Caldera Fill: 0 - 520 ft (8733 - 8215 ASL)
2. Bandelier Tuff: 520 - 5220 ft (8215 - 3532 ASL)
3. Paliza Canyon Andesite: 5220 - 5930 ft (3532 - 2825 ASL)
4. Tertiary Sediments: below 5930 ft (2825 ASL)

3.14.1 Analysis

Due to severe productivity damage during drilling, this well is scheduled to be redrilled. The temperature and pressure surveys in Figures 3.9 and 3.10 all, with the exception of survey S32 taken on 11/10/75, relate to the well before perforation of the casing in August 1975 (over the depth interval 3075 to 4195 ft).

A distinct temperature inversion is present at bottomhole; for example, temperature survey S12 (5/16/74) shows that the bottomhole temperature is less than 475°F. Cold-water injection, prior to temperature survey S13 (7/26/74) cooled well in the interval 4500 - 5000 ft; it, therefore, appears that the primary permeability is at this depth.

After casing perforation in August 1975, a downflow of water (temperature ~ 500°F) occurs from about 3000 ft depth (see survey labelled S32 in Figure 3.9); note that a temperature of 500°F was recorded at 3000 ft on 5/16/74 (Survey S12).

Flowing Survey S2 shows an extraordinary temperature profile. This is most readily explained by instrument error.

3.14.2 Summary

Permeability at 4500 ft (4252 ASL), and near 3000 ft (5746 ASL). Reservoir temperature given by Survey S12. Reservoir pressure at 4500 ft (4252 ASL) is 1260 psig.

3.15 <u>Well Baca No. 11</u> (Redondo Creek Area)

Ground Level Elevation: 9065 ASL
Zero Point for Downhole Surveys: 9070 ASL

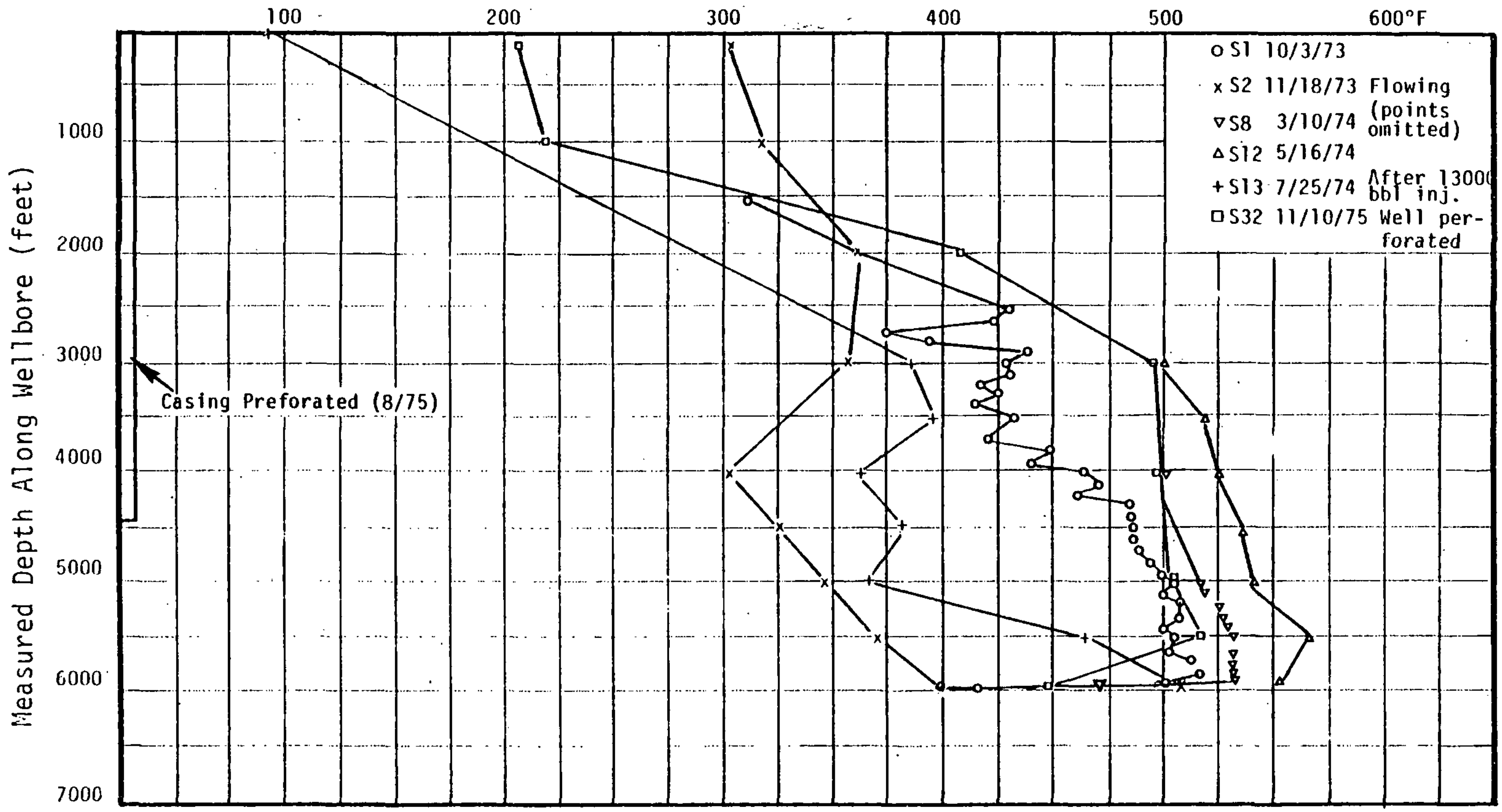

Figure 3.9. B-10 Temperatures

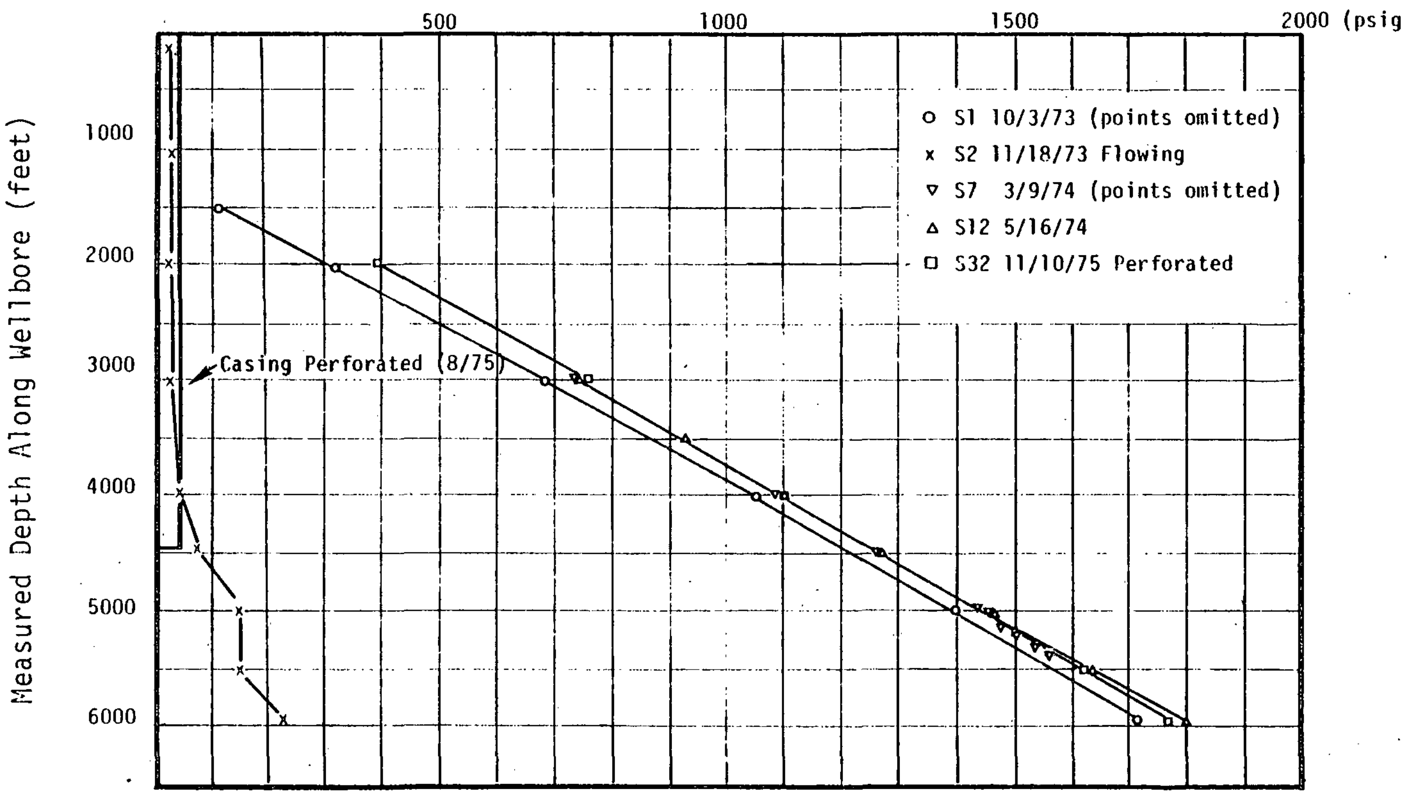

Figure 3.10. B-10 Pressures

Drilling Data:

1. (9/19/73 - 11/13/73) well drilled to a depth of 6931 ft (2182 ASL)
2. (9/26/74 - 10/13/74) scale buildup (3068 to 3937 ft) cleaned
3. (8/23/76 - 9/11/76) scale buildup (1565 to 4179 ft) cleaned

Casing Data: bottom of 9-5/8" casing set at 3380 ft (5688 ASL); 7" slotted liner below this depth

Formations Encountered During Drilling:

1. Caldera Fill: 0 - 320 ft (9065 - 8745 ASL)
2. Bandelier Tuff: 320 - 5440 ft (8745 - 3650 ASL)
3. Paliza Canyon Andesite: 5440 - 6565 ft (3650 - 2550 ASL)
4. Tertiary Sediments: below 6565 ft

3.15.1 Analysis

This well was drilled with aerated water. Steam entries were encountered at 3960 - 3970 ft; further entries however could not be detected because of the aerated water system used. The well exhibits a variety of downhole temperature/pressure profiles as illustrated in Figures 3.11 and 3.12. The stable profile S47 has the highest temperature measured at Baca, and a column of liquid water in the well. Other downhole pressure profiles in B-11 (see e.g., S14 and S25) indicate the presence of a low-density two-phase mixture in the wellbore. The well cycles when shutin (see Figure 3.13); a cycling profile was observed for three months after discharge in 1974.

The presence of a low-density profile in the wellbore indicates an "internal discharge" (Grant [1979b]). Although the well is shut, fluid is flowing in the wellbore. Two-phase fluid enters the well near bottomhole, flows up the wellbore and is injected at a higher permeable zone (Chasteen [1974]). This identification of the pressure profile in B-11 is different from the interpretation provided by Hartz [1976] of a similar pressure profile in B-15; Hartz assumes that the pressure profile in B-15

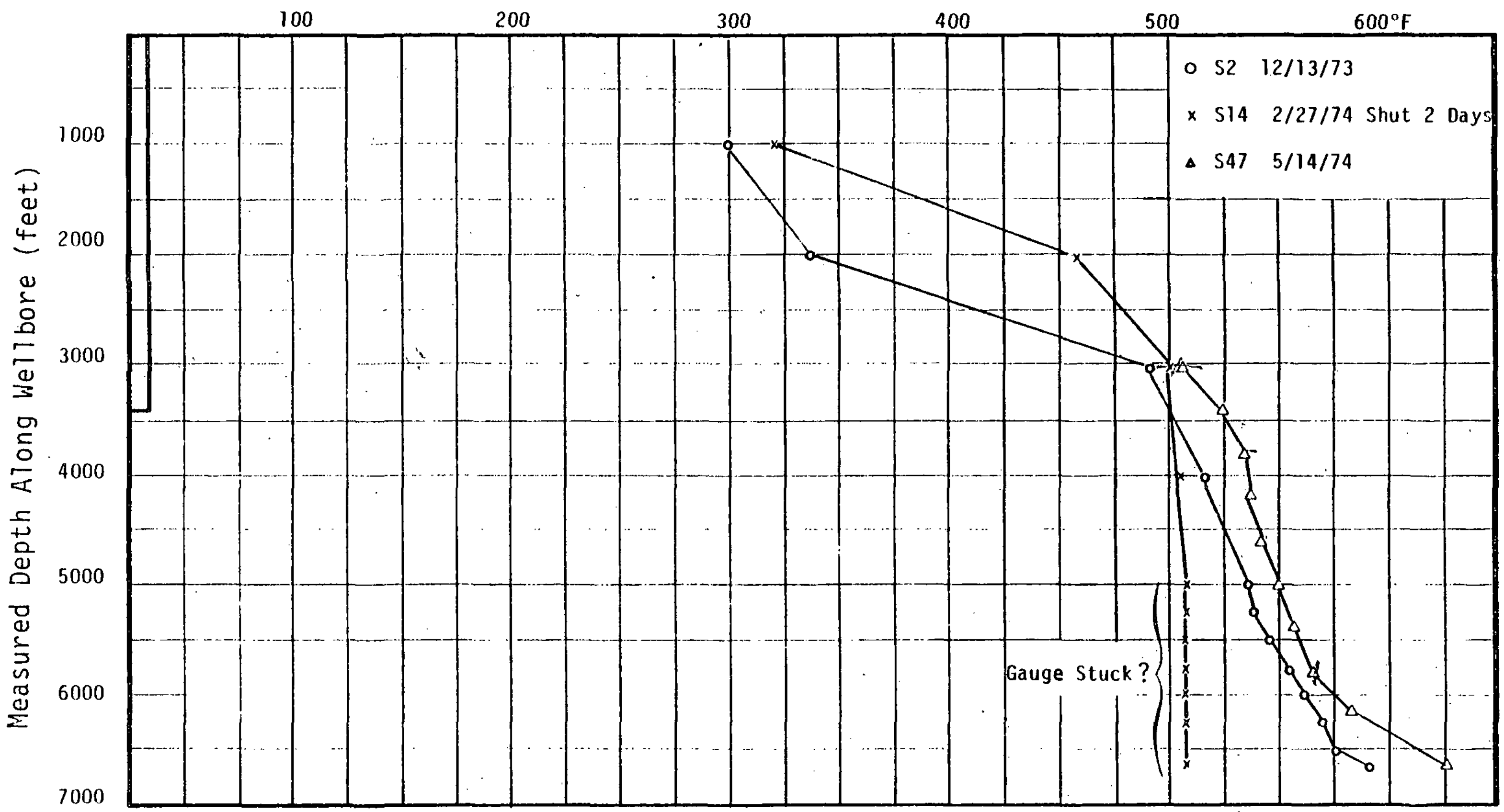

Figure 3.11. B-11 Temperatures

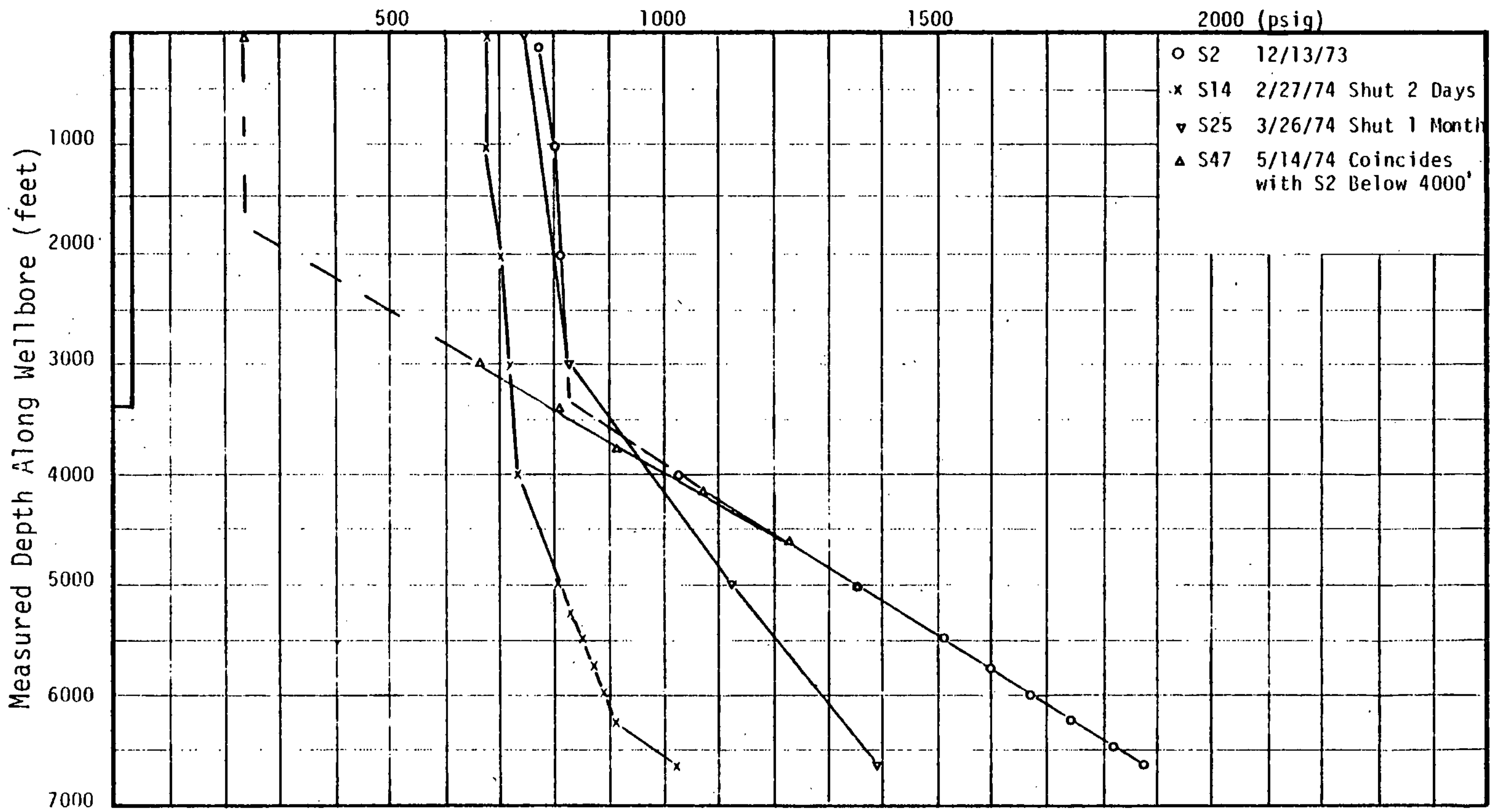

Figure 3.12. B-11 Pressures

represents the reservoir pressures, and hence infers the presence of an "underpressured steam zone" around B-15.

The internal discharge requires two permeable zones. One such zone is indicated at 6000 - 6250 ft by a persistent temperature feature; the other permeable zone can be equated with the steam entries at 3960 ft (say 4000 ft). With two permeable zones present, there is the possibility of persistent interzonal flow. The low-density profiles (internal discharge) represent upflows. Temperature Survey S14-T shows anomalous temperatures (measured temperatures imply that the fluid in the wellbore is liquid) below 4500 ft; these temperatures are most easily explained by an instrument error. (In case the measured temperatures below 4500 ft are real, this would indicate the presence of a downflow in the wellbore. It is thus possible that temperatures recorded in Survey S47-T in the depth range 4000 - 6000 ft are depressed by a small downflow; also the measured temperatures will correspond to reservoir temperatures at the inflow zone - say over the interval 3000 - 4000 ft.) The internal discharge indicates two-phase fluid at 6000 ft. Since the reservoir temperature at bottomhole (~ 6700 ft) is over 627°F, the boiling temperature at 6000 ft should be at least 600°F.

Some additional information regarding formation permeability and fluid state can also be derived from the pressure/temperature measurements made during the cycling phase of the well. Figure 3.13 shows pressure and temperature measured at bottomhole (beneath the lowest permeable zone) during one period of the cycle (with the well shut). Although the pressure exhibits large oscillations the temperature changes only very slightly. The pressure at 6000 ft (lower feed zone) cycles with the rate of the boiling fluid entering the well at this depth. When the pressure at 6000 ft falls to its

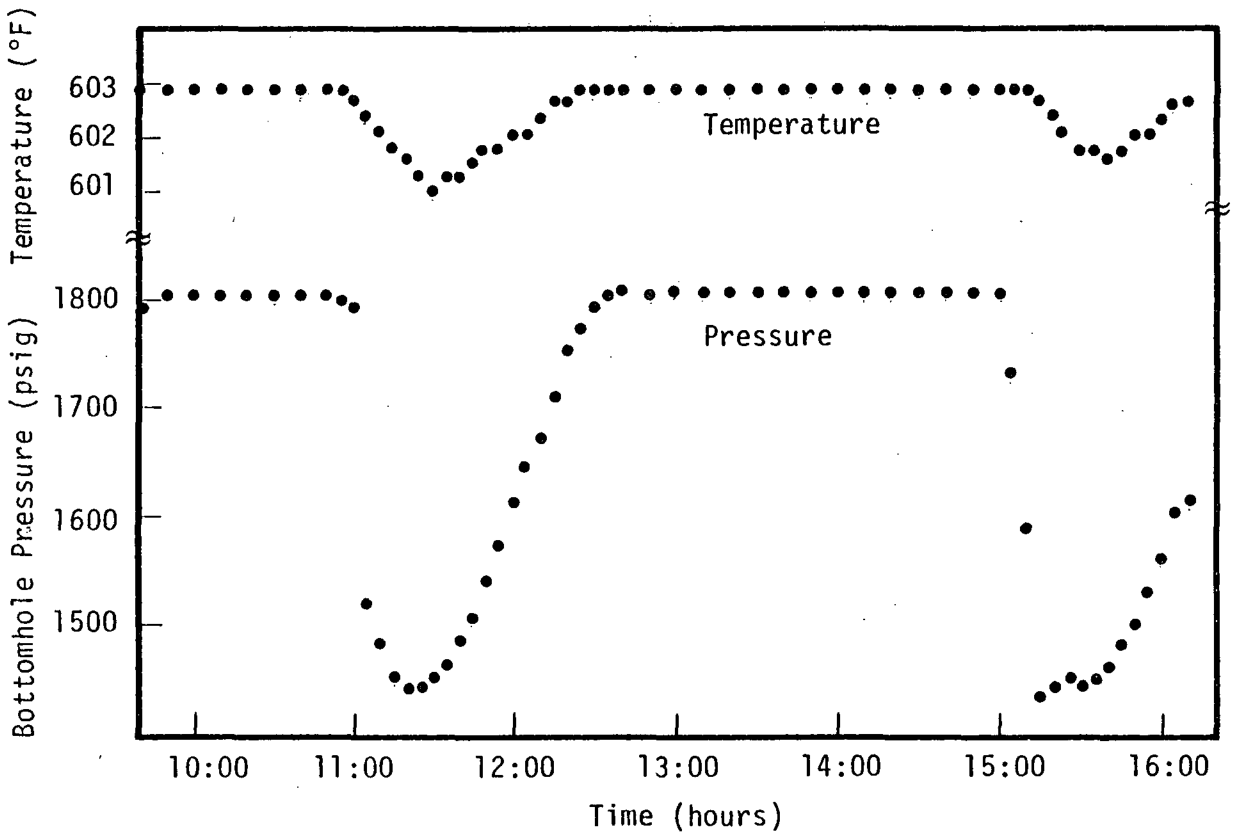

Figure 3.13. Bottomhole (6650 ft) Pressure/Temperature Survey S65 Taken on 1/25/75 Showing the Cyclic Response of B-11 When Shut (Well Shut at 10:35 hours on 11/17/74).

minimum, so does the pressure at 6650 ft; also the temperature at 6650 ft drops down to the saturation value. As the pressure at 6000 ft recovers, so does the pressure at 6650 ft; the bottom of the well now fills with liquid water. During the recovery phase, the temperature recovers only a little (mainly by conduction) before the next cycle again reduces the temperature below 601°F. Thus, although reservoir temperature at 6650 ft exceeds 627°F, the repeated flashing of the fluid column prevents the well warming up to this temperature.

The discharge enthalpy of B-11 is quite variable, and is usually much above that of liquid water (enthalpy of liquid water at 627°F ~ 658 Btu/lb). This indicates two-phase conditions in some fluid zone feeding the well. The preceding analysis implies that there is two-phase fluid at 6000 ft (because of the internal discharge observed) and at 4000 ft (because of the steam entries encountered during drilling). A different interpretation of the discharge enthalpy data is given in Hartz [1976]:

> "The produced enthalpy of Baca 11 is certainly higher than its reservoir fluid enthalpy. A closer look at the Baca 11 production characteristics reveals an interesting phenomenon. On Figure 18 (Figure 3.14 of this report) is a plot of the produced enthalpy of Baca 11 as a function of the wellbore flowing pressure at a depth of 4000 ft. When the flowing pressure is above the steam zone pressure, the produced fluid enthalpy is the same as the reservoir fluid enthalpy, indicating no steam production. However, when the flowing pressure at 4000 ft falls below 700 psig, sufficient to exert a drawdown on the steam zone, the produced enthalpy reflects the increase due to production of steam in addition to the hot water reservoir fluids. As stated previously, this steam cannot exist in pressure communication with the hotter and higher pressured hot water without a much higher temperature and correspondingly higher pressure in the zone."

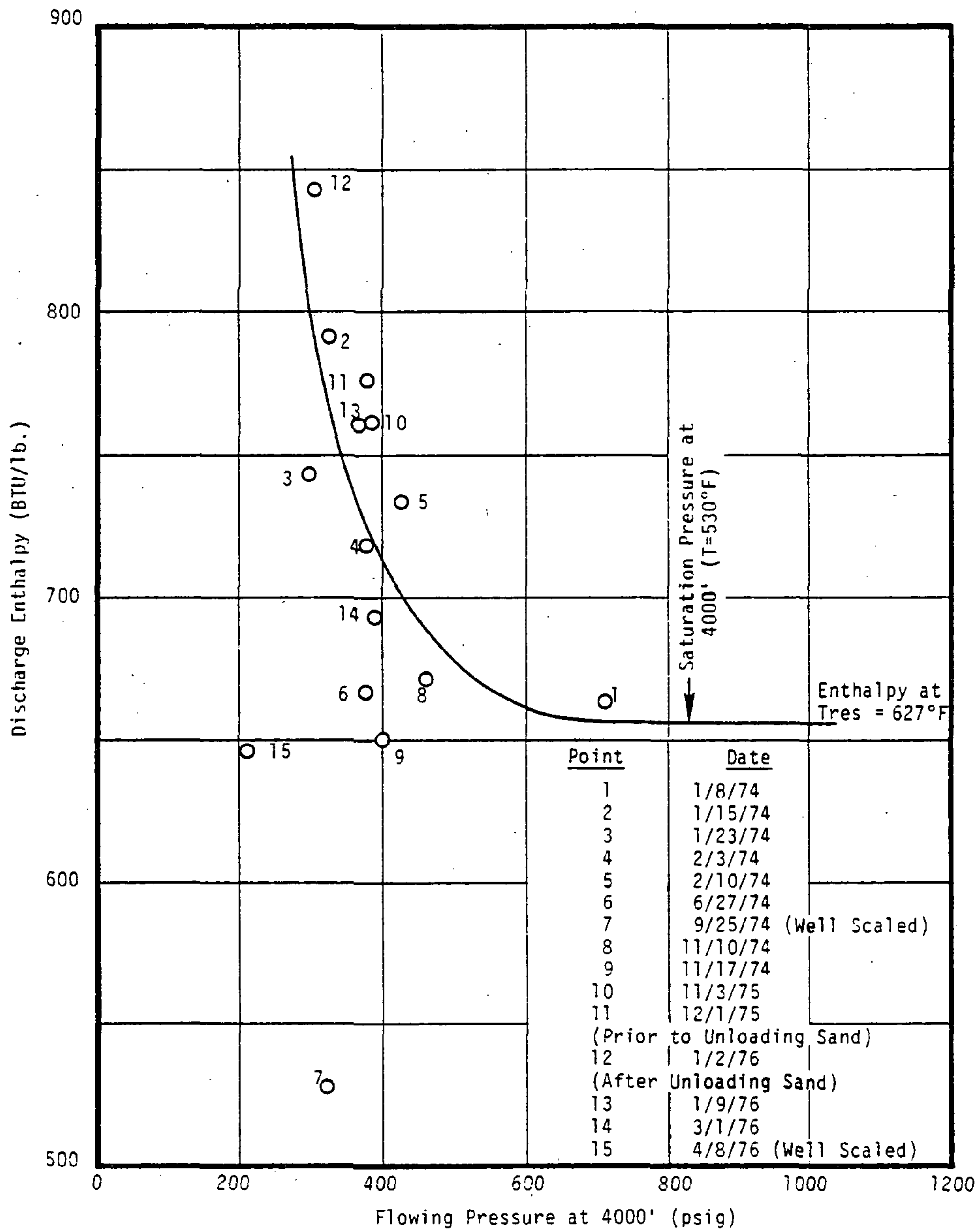

Figure 3.14. Discharge Enthalpy as a Function of Flowing Pressure at 4000 ft (Hartz [1976]).

In other words, Hartz hypothesizes that the high-enthalpy discharge is caused by the production of steam from a steam zone at 4000 ft depth (~ 5075 ASL) with a pressure of 700 psig. Let us now examine the consequences of this hypothesis. Figure 3.15 shows the stable downhole pressure profile. The stable pressure at 4000 ft is 1040 psig - some 340 psi above 700 psig. In case the steam zone at 4000 ft has a pressure of 700 psig, water will flow into this zone. It is possible to estimate the magnitude of this implied water flow into the steam zone at 4000 ft. During the flow tests used to obtain the discharge enthalpy data of Figure 3.14, well flowed at a rate of 200,000 - 300,000 lb/hr. A fall in pressure at 4000 ft from 700 to 300 psig results in an increase in discharge enthalpy from 655 to about 800 Btu/lb. This is equivalent to a steam discharge of about 80,000 lb/hr. The steam zone, must, therefore, have a productivity of 80,000/400 = 200 lb/hr.psi. We will now assume that the fluid discharge coming from zones other than that at 4000 ft has a temperature of 627°F (i.e., measured bottomhole temperature). Flow test 1 shows a pressure at 4000 ft of 700 psig; this would correspond to a bottomhole pressure of at least 1000 psig. With a flow rate of $200,000^+$ lb/hr, productivity of the lower zone exceeds 200,000/(1900 - 1000) = 200 lb/hr. psi.

We will now estimate the upflow in the well that would be induced by the presence of the underpressured zone at 4000 ft. It appears that the water entering at bottomhole would flash in formation, and two-phase fluid would flow up the well. The injectivity for this steam-water mixture at 4000 ft should at least equal the productivity for steam (~ 200 lb/hr.psi); as a matter of fact, the injectivity at 4000 ft would be larger than the steam productivity due to the greater density of the two-phase fluid being injected. The bold line on Figure 3.15 shows the corresponding pressure profile (this implies that B-11 would have a stable profile similar to that of B-15). The flow rate is about 80,000 lb/hr, corresponding to 400 psi drawdown at the lower zone and equal overpressure at the upper. Although B-11 does exhibit such a

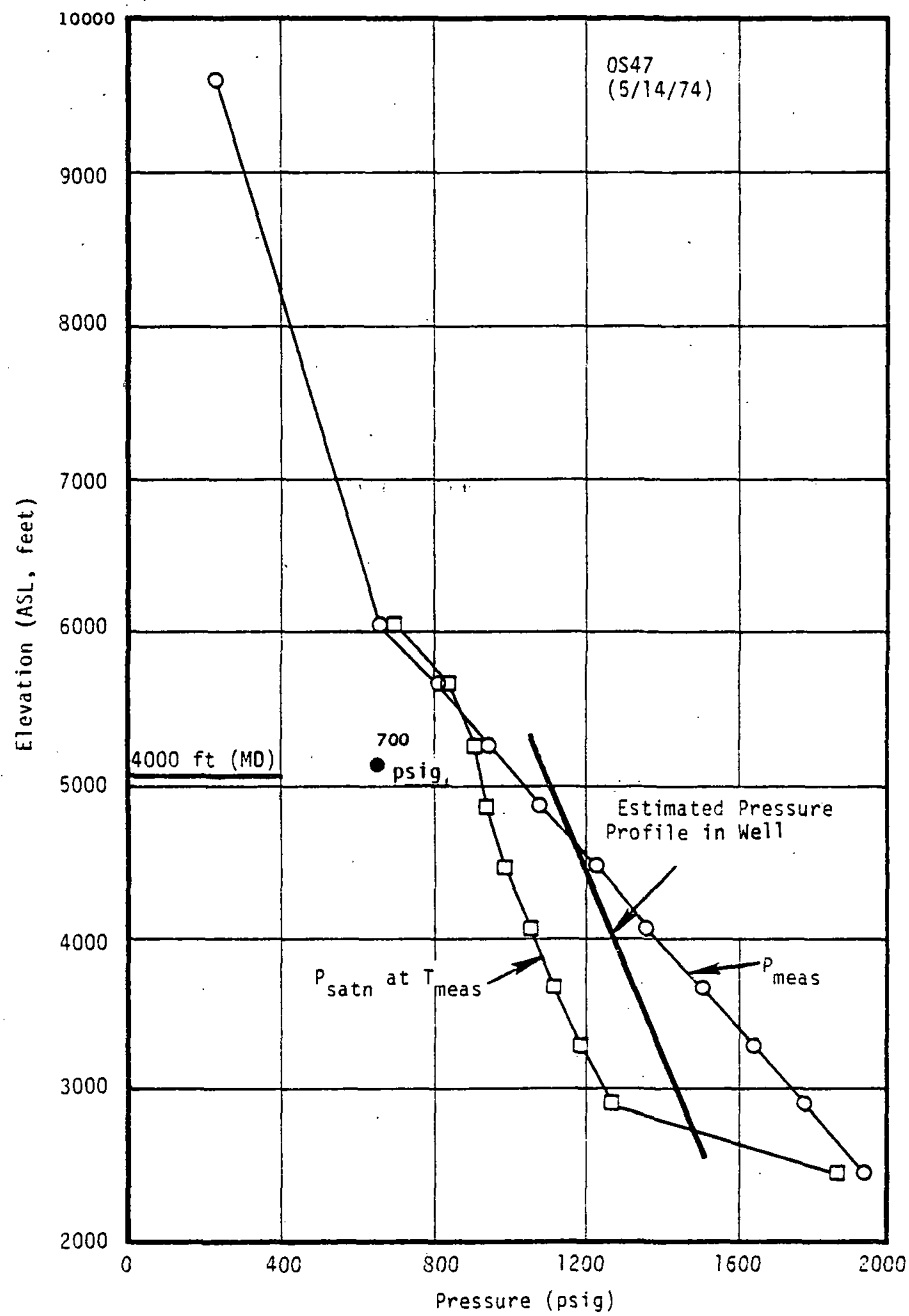

Figure 3.15. Estimated Pressure Profile for B-11 Corresponding to the Presence of an Under Pressured Steam Zone at 4000 ft (Pressure in Steam Zone ∿ 700 psig).

pressure profile at times, this pressure profile does not persist. The bottomhole pressures in B-11 exhibit a cycling response (Figure 3.13); this implies that the upflow is sufficiently small such that it collapses periodically. An upflow of 80,000 lb/hr is far above that required to sustain flow. Thus, were there an underpressured zone at 4000 ft, the well will not contain a column of water at any time. We, therefore, conclude that there is no underpressured steam zone at 4000 ft.

3.15.2 Summary

Permeable zones at 6000 ft (3102 ASL) and 4000 ft (5075 ASL), both two-phase. Reservoir temperature 627°F at bottomhole. Temperatures in the interval 3000 - 4000 ft (6068 - 5075 ASL) given by S47. Temperatures in the depth range 4000 - 6000 ft (5075 - 3102 ASL) may be suspect because of possible interzonal flow. No underpressured steam zone.

3.16 Well Baca No. 12 (Redondo Creek Area)

Ground Level Elevation: 8427 ASL
Zero Point for Downhole Surveys: 8441 ASL
Total Depth of Well: (6/19/74 - 8/19/74) 9212 ft (-774 ASL)
Casing Data: 9-5/8" casing bottom set at 3540 ft (4891 ASL); 7" slotted liner hung from 3343 ft (5088 ASL) to 9211 ft (-773 ASL)
Formations Encountered During Drilling:

1. Gravel/Volcanic Debris: 0 - 160 ft (8427 - 8267 ASL)
2. Bandelier Tuff: 160 - 6460 ft (8267 - 1970 ASL)
3. Paliza Canyon Andesite: 6460 - 7380 ft (1970 - 1070 ASL)
4. Abiquiu Tuff: 7380 - 7575 ft (1070 - 875 ASL)
5. Permian Redbeds: below 7575 ft.

3.16.1 Analysis

Because of its poor productivity, B-12 is being used for water disposal. Figures 3.16 and 3.17 show the various downhole temperature and pressure surveys respectively.

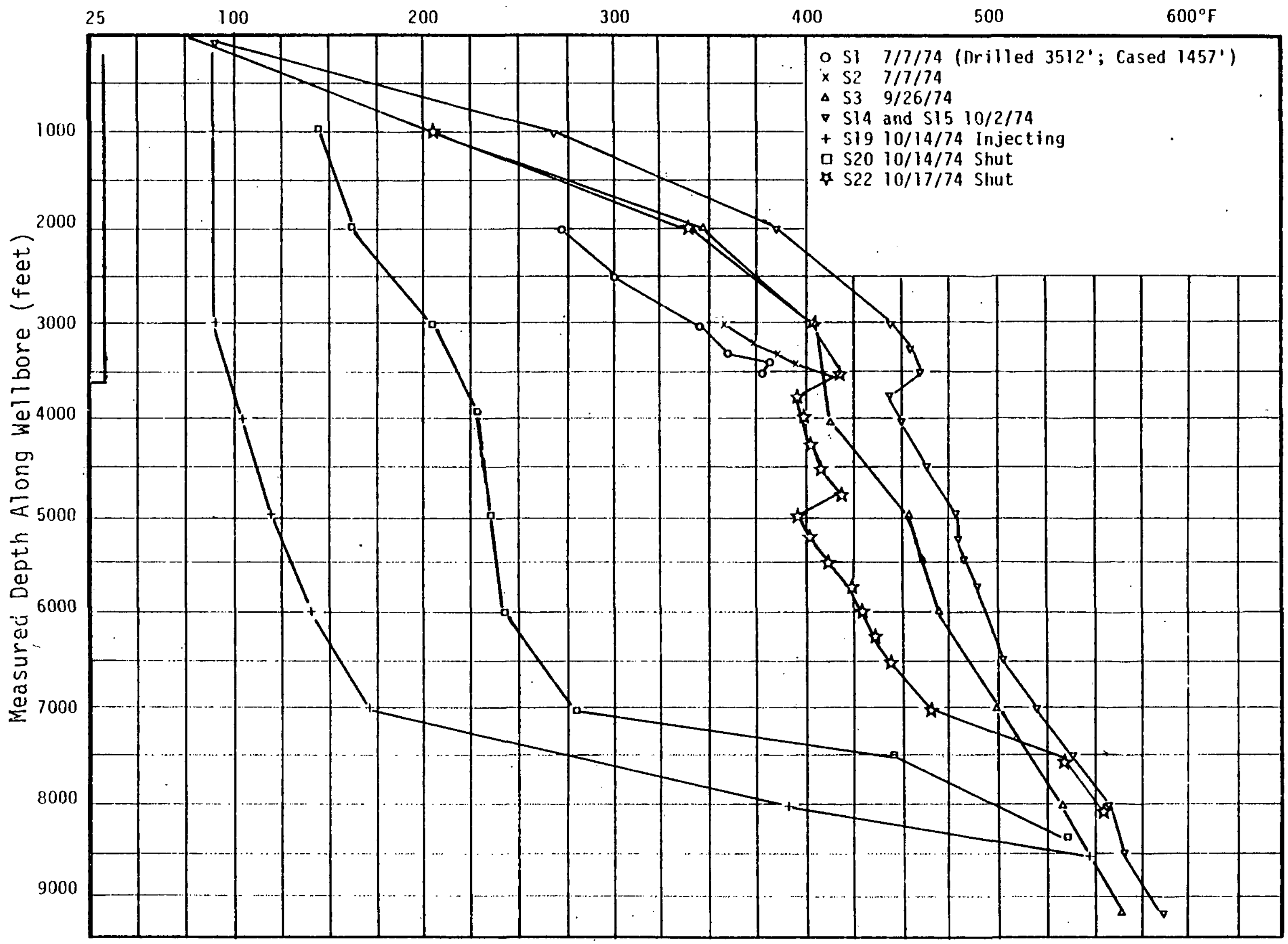

Figure 3.16. B-12 Temperatures

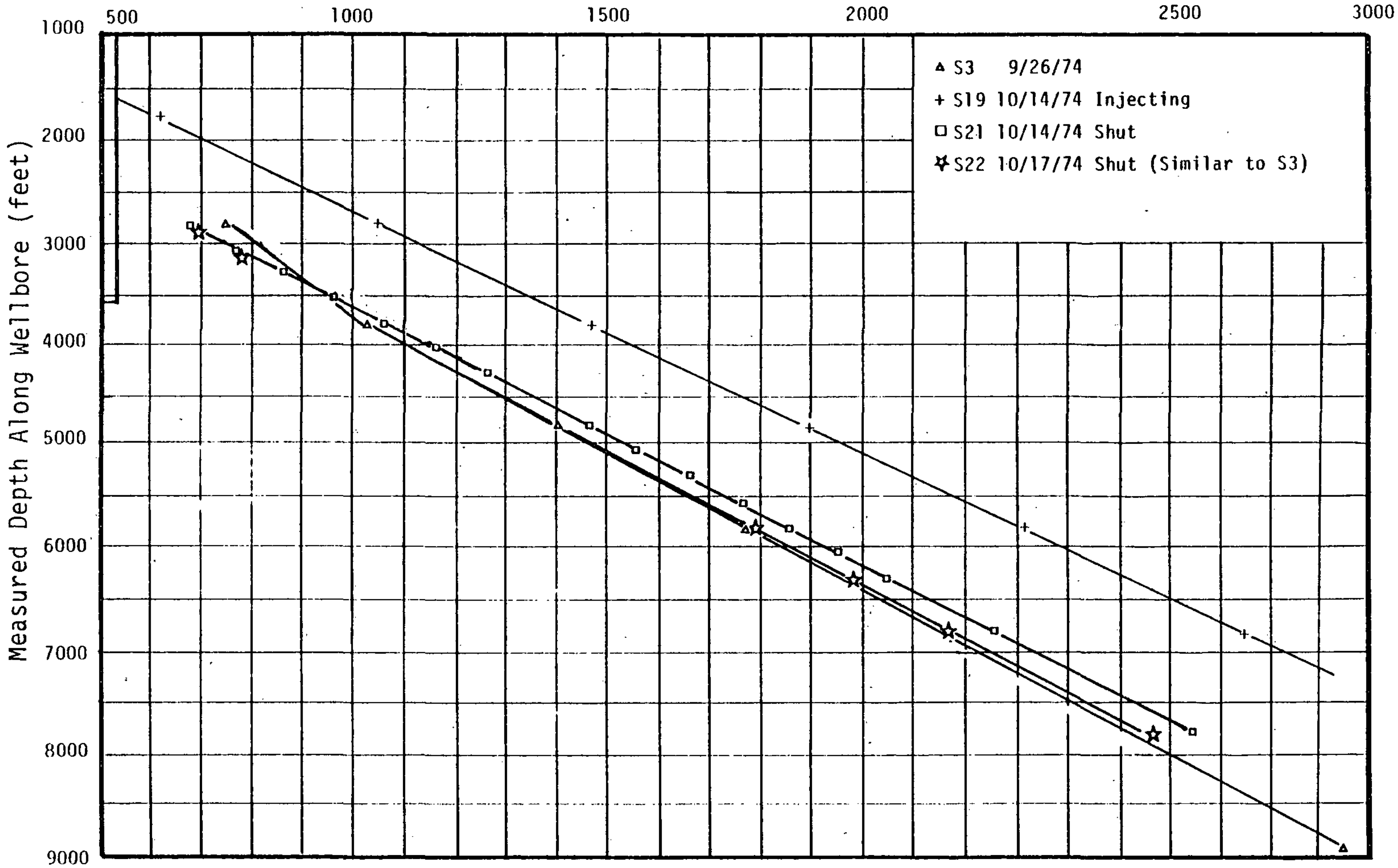

Figure 3.17. B-12 Pressures

Temperature survey S19, taken while injecting, indicates that the deepest permeability in the well is near 7000 ft. The change in temperature gradient at 3000 - 4000 ft (Temperature Survey S19) would appear to imply some water loss just below the 9-5/8" casing shoe at approximately 3600 ft. The presence of a permeable zone at 3600 ft is confirmed by a temperature peak in the stable profile (see e.g., Survey S14).

The pressure surveys (Figure 3.17) do not form a clear pivot during warmup; hence, it is not possible to draw any definite inferences from the pressure data.

The stable temperature profile (S14/S15) has sufficient detail in it to indicate that convective effects in the wellbore are not important, and that it probably approximates reservoir temperatures in the open hole. Since a temperature peak is present at 3500 ft the downhole temperatures near here must also reflect a peak in the reservoir temperature. Note that a temperature inversion occurs near 3700 ft. We conclude that the stable temperature profile S14 probably indicates reservoir temperatures from 3000 ft to bottomhole.

3.16.2 Summary

Permeability at 3500 ft (4931 ASL) and 7000 ft (1442 ASL). Unable to decide which permeable zone is dominant. Reservoir temperatures 3000 ft - bottomhole (5430 to - 774 ASL) given by temperature surveys S14 and S15.

3.17 Well Baca No. 13 (Redondo Creek Area)

Ground Level Elevation: 9292 ASL
Zero Point for Downhole Surveys: 9304 ASL

Total Depth Drilled: (8/23/74 - 10/27/74) 8228 ft (1183 ASL)
Casing Data: bottom of 9-5/8" casing set at 3499 ft (5808 ASL); 7" slotted liner is hung from 3340 ft (5966 ASL) to 8200 ft (1212 ASL)
Formations Encountered During Drilling:

1. Caldera Fill: 0 - 560 ft (9292 - 8734 ASL)
2. Bandelier Tuff: 560 - 5712 ft (8734 - 3660 ASL)
3. Paliza Canyon Andesite: 5212 - 8090 ft (3660 - 1325 ASL)
4. Permian Redbeds: below 8090 ft

3.17.1 Analysis

This well has discharged at rates in excess of 300,000 lb/hr. The average discharge enthalpy is approximately 558 Btu/lb (~ enthalpy of liquid water at 556°F). Chemical analysis of discharge stream indicates an incondensable gas content of over 0.8 percent by weight. Hartz [1976] observes "An important feature of Baca 13's production characteristic is that the flow rates and pressures fluctuated continually during the entire test. Ranges of fluctuation were on the order of 10 to 15 psig and rates fluctuated about 10 percent during cycle. Cycles lasted about two hours from peak to peak and were very regular during the entire test." Cycling behavior during discharge indicates that Baca 13 is producing from two feed zones (Grant, et al. [1979]).

During drilling of Baca 13, drilling breaks occured at 4840 - 4880 ft and at 5520 ft; furthermore, a highly fractured zone was encountered at 5380 - 5400 ft.

The temperature and pressure surveys are plotted in Figures 3.18 and 3.19 respectively. Stable temperature profiles S16 and S41 have a temperature peak at about 4500 ft; this indicates a permeable zone. A temperature inversion (S16 and S41) occurs immediately below 4500 ft, and a break in temperature gradient is observed at about 6000 ft (S16 and S41). It is noteworthy that both the temperature inversion at 4500 ft and the break in gradient at 6000

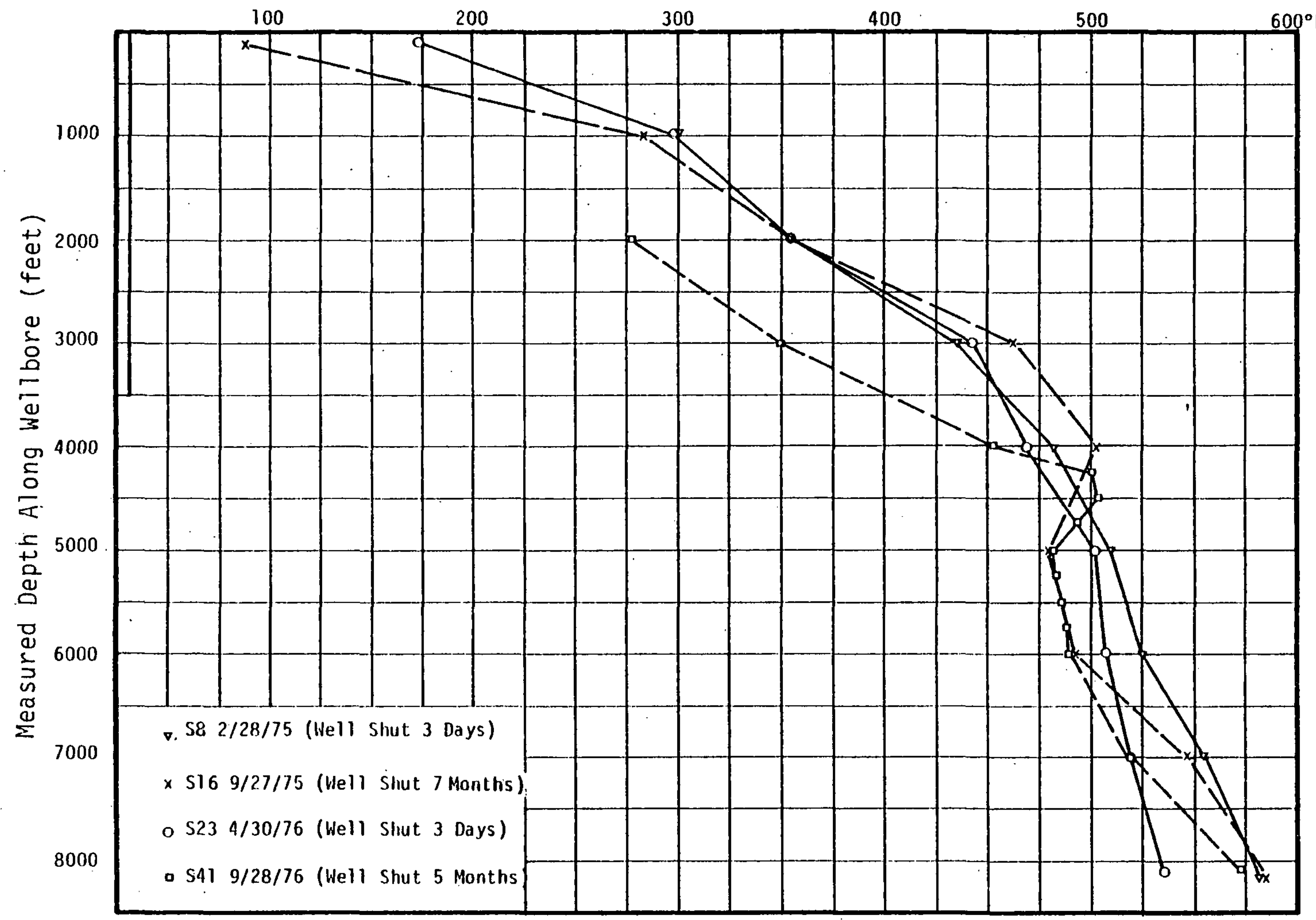

Figure 3.18. B-13 Temperatures

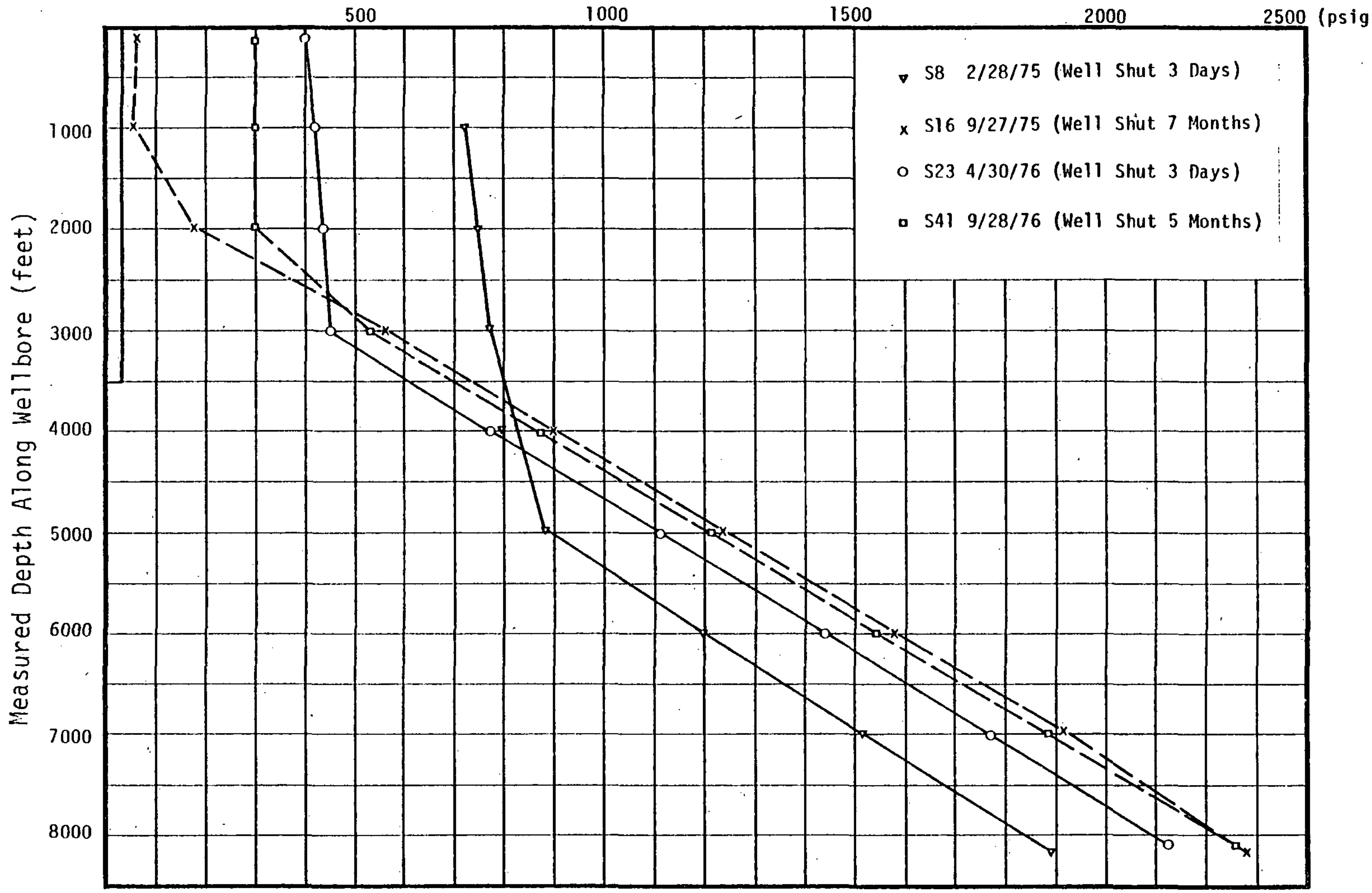

Figure 3.19. B-13 Pressures

ft are absent in temperature surveys S8 and S23 taken 3 days after shutting the well. The latter observation implies that at steady state (S16, S41) there is a small downflow of fluid from 4500 ft; this fluid is injected at about 6000 ft. Because of the downflow, temperatures over the interval 4500 - 7000 ft recorded in S16 and S41 are most likely depressed. S16 gives the reservoir temperatures at 4500 ft and below 7000 ft. The reservoir fluid is two-phase at 4500 ft, and is single-phase compressed liquid at 6000 ft.

After discharge, pressures recover rather slowly (Figure 3.19); this suggests that the pressure response in B-13 is governed by the two-phase zone at 4500 ft. Reservoir pressure (S16) at 4500 ft is 1070 psig.

3.17.2 Summary

Permeability at 4500 ft (~ 4836 ASL) and at 6000 ft (~ 3377 ASL). Reservoir two phase at 4500 ft and single phase at 6000 ft. Reservoir temperature at 4500 ft and below 7000 ft given by temperature survey S16. Reservoir pressure at 4500 ft is 1070 psig.

3.18 Well Baca No. 14 (Redondo Creek Area)

Ground Surface Elevation: 8605 ASL
Zero Point for Downhole Surveys: 8611 ASL
Drilling Data: (11/16/74 - 2/24/75) drilled to a total depth of 6824 ft (2067 ASL); later plugged back to 5780 ft (3059 ASL) due to sloughing problems.
Casing Data: bottom of 9-5/8" casing set at 3074 ft (5579 ASL); 8.75" open hole below 3074 ft.
Formations Encountered During Drilling:

1. Caldera Fill: 0 - 280 ft
2. Bandelier Tuff: 280 - 5800 ft (8605 - 8196 ASL)
3. Andesite: 5800 - 6140 ft (8196 - 3040 ASL)
4. Santa Fe Sand: 6140 - 6700 ft (3040 - 2725 ASL)
5. Redbeds: below 6700 ft (2725 - 2180 ASL).

3.18.1 Analysis

Due to poor productivity, Baca 14 is being used for injection. Figure 3.20 and 3.21 show the temperature and pressure surveys respectively. Temperatures during injection (S5-T) indicate water loss at 4750 ft with perhaps some additional loss at 5500 ft. Post-injection surveys (S6, 7-T) show that the region 4000 - 5000 ft has been cooled.

The stable temperature profile is shown by S3-T and S4-T. As the well has generally poor permeability, the stable profile probably represents the reservoir temperatures over the open section 3100 - 6800 ft. Temperature survey S9 shows that temperatures at 2000 ft and 3000 ft exceed 365°F and 415°F respectively; we, therefore, conclude that the stable temperature profile in the well does not reflect reservoir temperatures in the cased section of the hole.

The pressures show a pivot near 3000 ft, but this may be the result of transient effects. The injection results imply that the permeable zone is deeper than 3000 ft.

3.18.2 Summary

Permeable zone near 4500 ft (~ 4251 ASL). Reservoir temperatures over the open section 3074 - 6824 ft (5579 ASL to 2067 ASL) given by temperature surveys S3 and S4. Minimum reservoir temperatures in the interval 1000 - 3000 ft (7621 ASL to 5652 ASL) given by S9. Probably reservoir pressure at 4500 ft (~ 4251 ASL) is 1215 psig.

3.19 Well Baca No. 15 (Redondo Creek Area)

Ground Level Elevation: 9119 ASL
Zero Point for Downhole Surveys: 9125 ASL
Total Depth Drilled: (4/29/75 - 6/12/75) 5505 ft (3755 ASL)

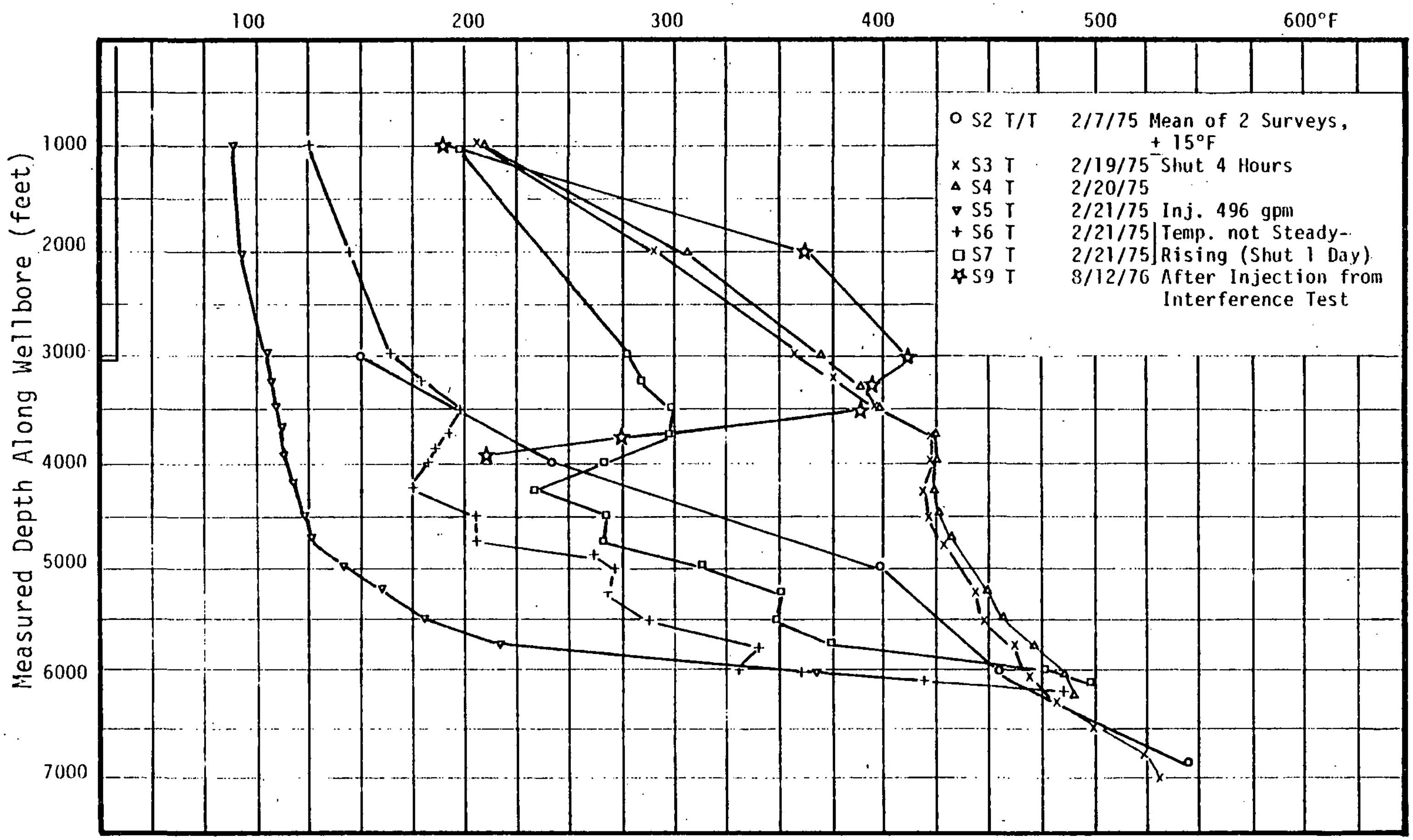

Figure 3.20. B-14 Temperatures

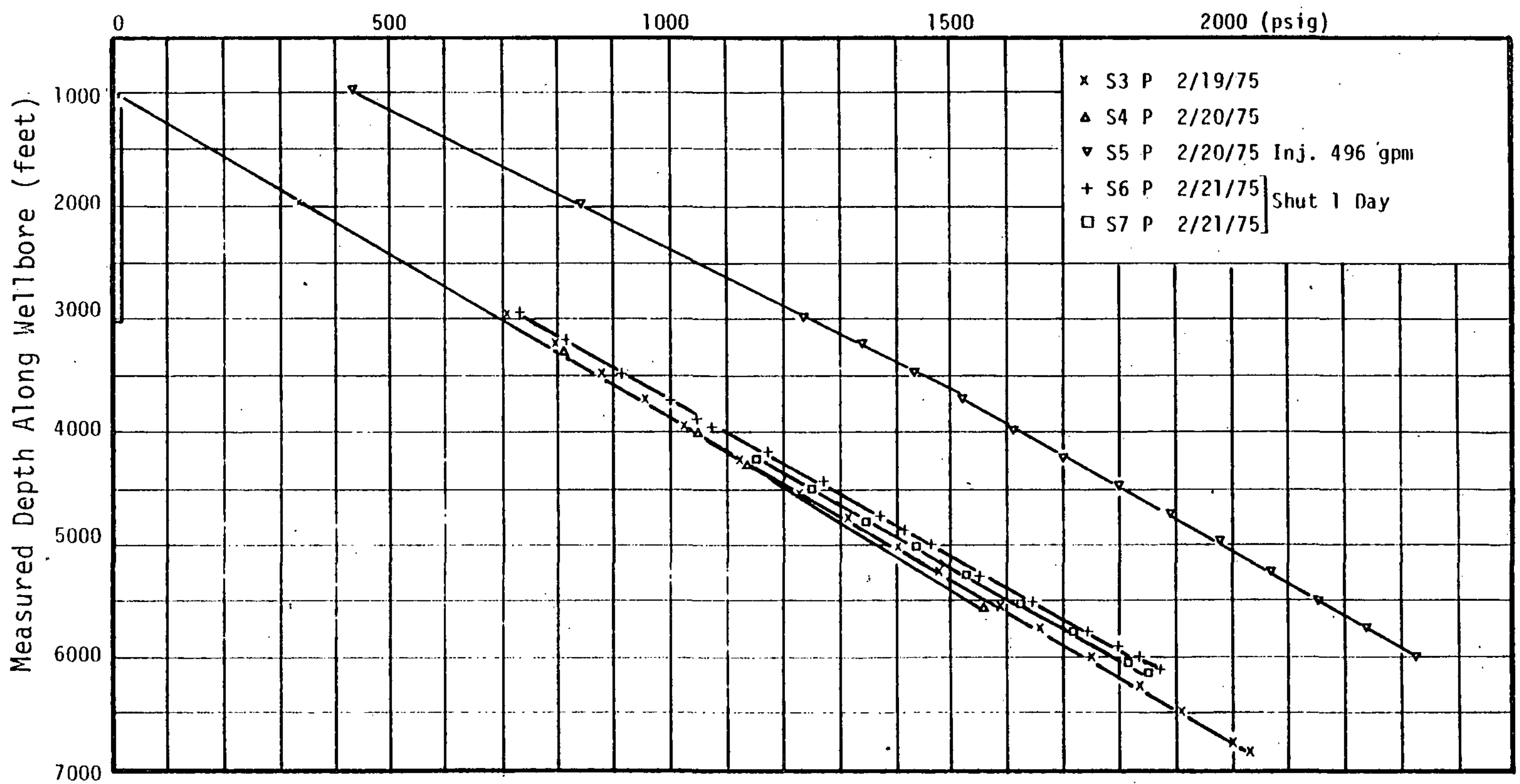

Figure 3.21. B-14 Pressures

Casing Data:

1. (4/29/75 - 6/12/75) bottom of 9-5/8" casing set at 2509 ft (6610 ASL); 8.75" open hole below 2509 ft
2. (9/13/76 - 9/19/76) 7" slotted liner set over the depth interval 2379 - 5503 ft; 2-3/8" tubing string from surface to 5472 ft.

Formations Encountered During Drilling:

1. Caldera Fill: 0 - 350 ft (9119 - 8779 ASL)
2. Bandelier Tuff: 350 - 5100 ft (8769 - 4141 ASL)
3. Paliza Canyon Andesite: below 5100 ft

3.19.1 Analysis

All downhole pressure/temperature surveys in B-15 show a similar picture. Temperature and pressure surveys (S13) are shown in Figure 3.22. The measured pressure gradient lies between that of water and steam; the wellbore apparently contains a mixture of water and steam. The pressure profile is that of a discharging well. The well in its stable shut state contains an "internal discharge," two-phase fluid entering the well toward bottomhole, flowing up the wellbore and being injected near the casing shoe. The measured pressure can be compared with the reservoir pressure gradient. Near well bottom, the pressure in the well is much below the reservoir pressure; just beneath the casing shoe it exceeds the reservoir pressure. (A similar profile for B-11 was interpreted by Chasteen [1974] as an internal discharge.) Since the well is at all times in a flowing state, no direct measurement of reservoir fluid properties is possible. Reservoir pressure and temperature towards bottomhole must exceed the values measured in the well, and the pressure gradient identifies the fluid entering the well as two-phase.

The drawdown at bottomhole (relative to reservoir pressure defined by the other wells) is larger than the overpressure near casing shoe. Therefore, the upper zone permeability is larger than that of the lower zone. There was lost circulation at 2525 ft (just below casing shoe); this probably defines the upper permeable zone.

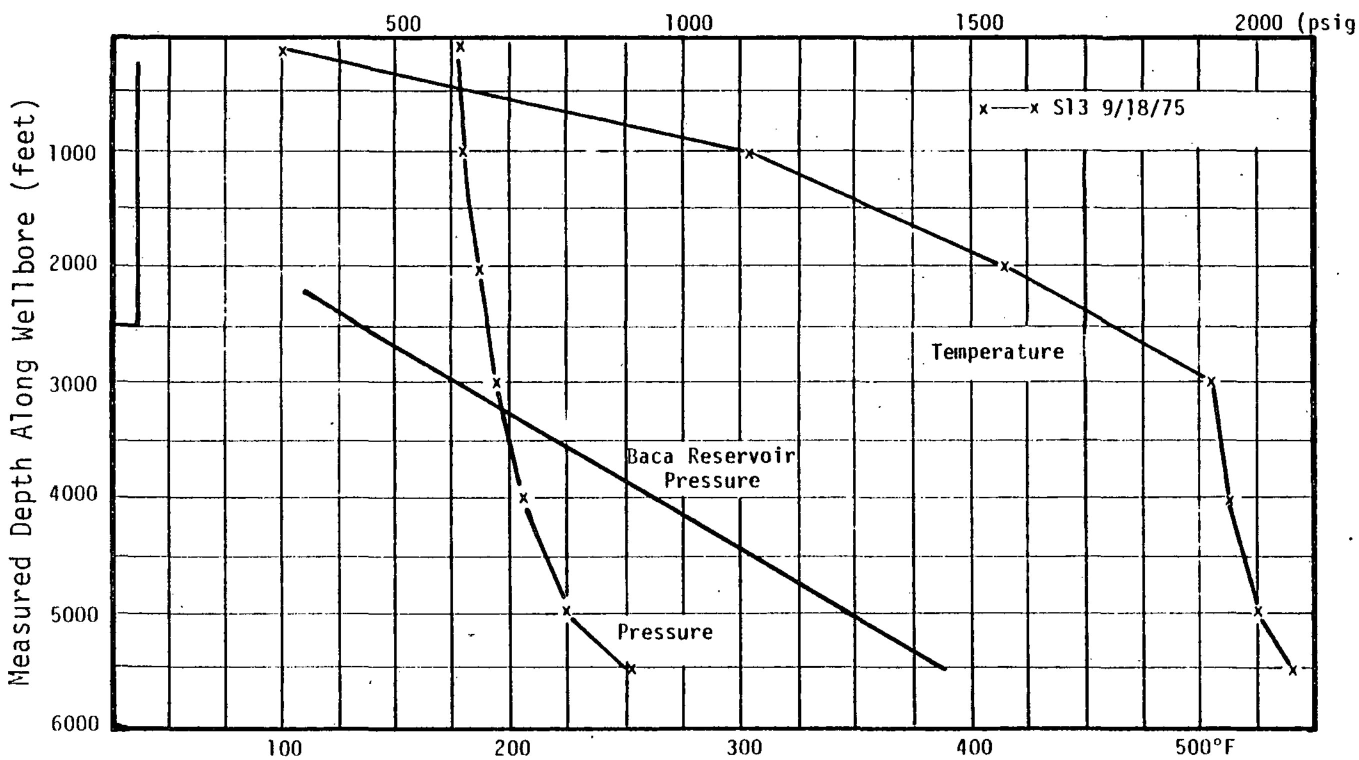

Figure 3.22. B-15 Pressure and Temperature

In production tests, the well discharges high-enthalpy fluid. Since this fluid derives primarily from the upper zone, it is very likely that the upper feed zone contains two-phase fluid.

B-15 is by a considerable margin the most productive well at Baca. It would probably therefore be worth additional effort to locate the permeable horizons in this well precisely (perhaps by injection test) in order to see if these correlate with any structure that might be present in another well.

3.19.2 Summary

Permeable horizons near bottomhole (3755 ASL) and near casing shoe (6610 ASL). Upper zone has higher permeability. Since the well has an "internal discharge", reservoir temperature/pressure must exceed those measured in the well. Both feed zones probably contain two-phase fluid.

3.20 Well Baca No. 16 (Redondo Creek Area)

Ground Level Elevation: 9622 ASL
Zero Point for Downhole Surveys: 9632 ASL
Total Depth Drilled: (6/19/75 - 8/21/75) 7002 ft (2795 ASL)
Casing Data: bottom of 9-5/8" casing set at 2905 ft (~ 6720 ASL); 8.75" open hole below 2905 ft
Formations Encountered During Drilling:

1. Caldera Fill: 0 - 380 ft (9622 - 9242 ASL)
2. Redondo Creek Rhyolite: 380 - 880 ft (9242 - 8743 ASL)
3. Bandelier Tuff: 880 - 5560 ft (8743 - 4130 ASL)
4. Paliza Canyon Andesite: 5560 - 6880 ft (4130 - 2905 ASL)
5. Tertiary Sands: below 6880 ft

3.20.1 Analysis

Temperature/pressure surveys taken during drilling are shown in Figures 3.23 and 3.24. Figures 3.25 and 3.26 give the temperature/ pressure surveys for the completed well. The shallow pressures (Figure 3.24) do not appear to differ significantly from

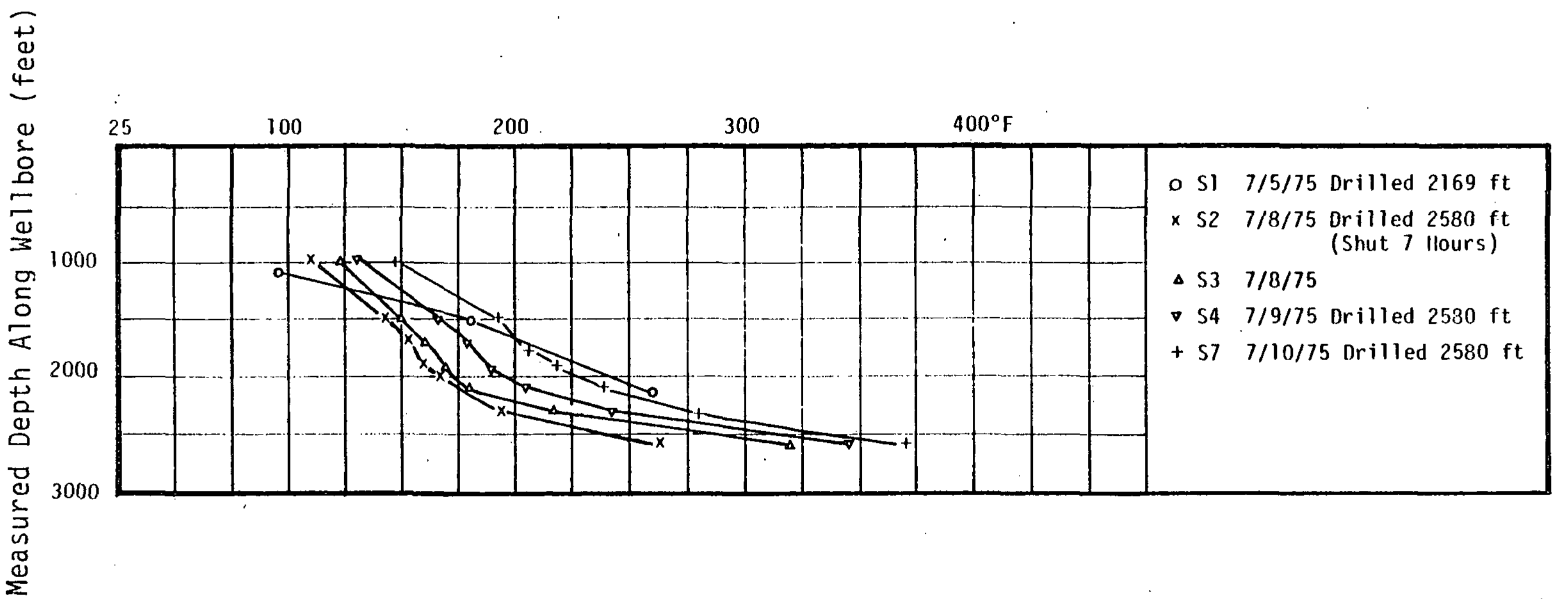

Figure 3.23. B-16 Temperatures During Drilling

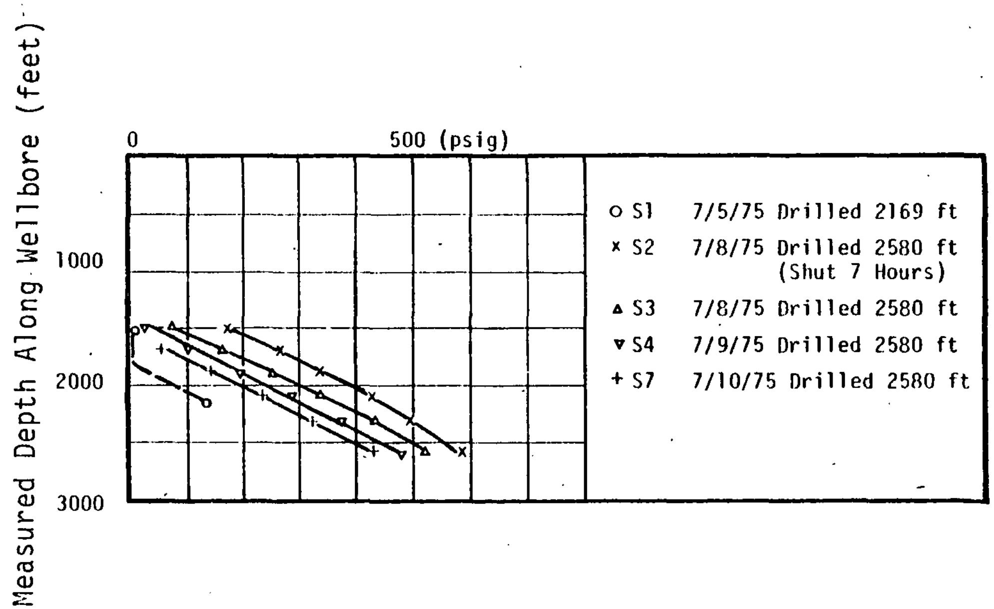

Figure 3.24. B-16 Pressures During Drilling

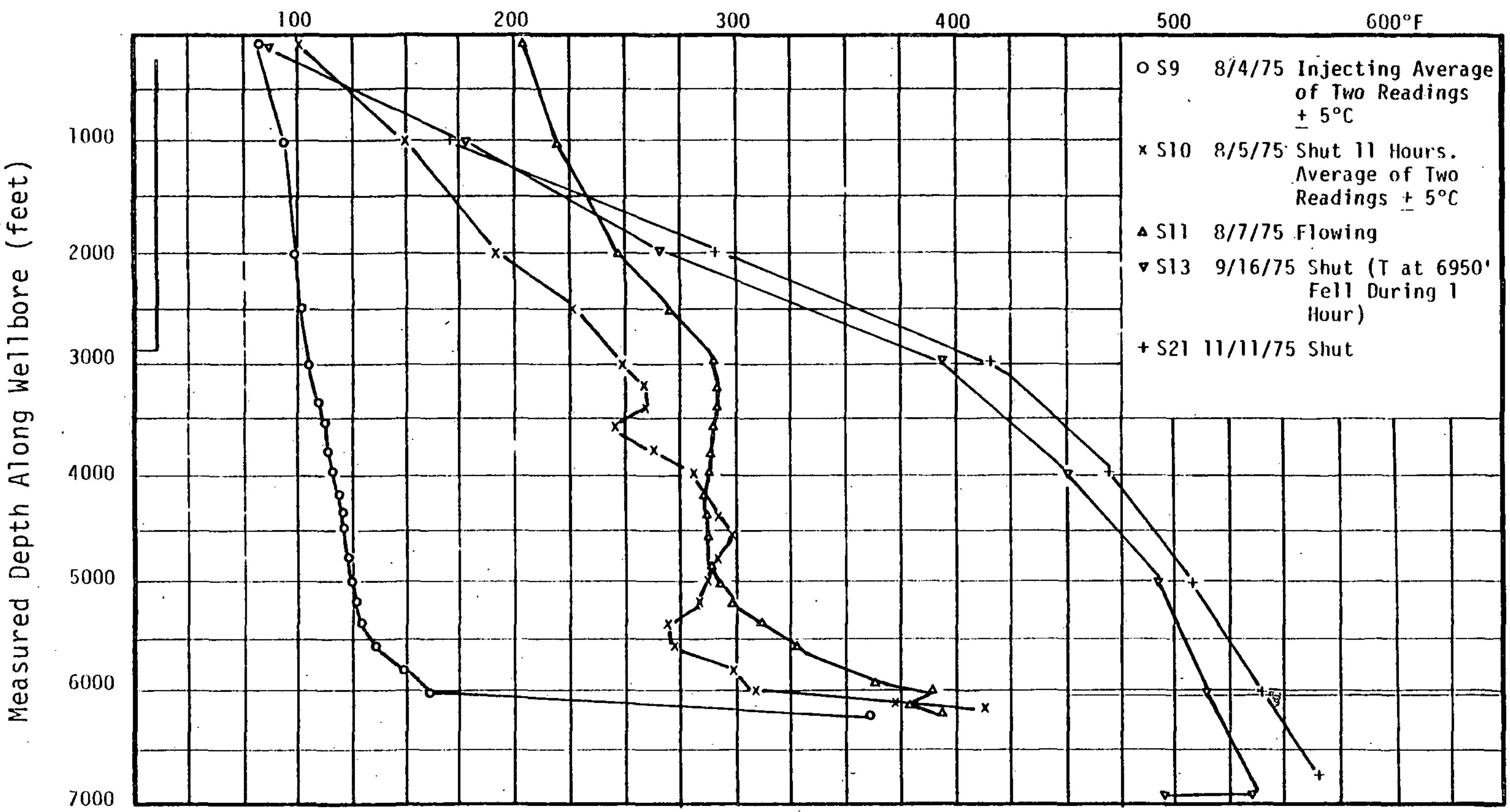

Figure 3.25. B-16 Temperatures

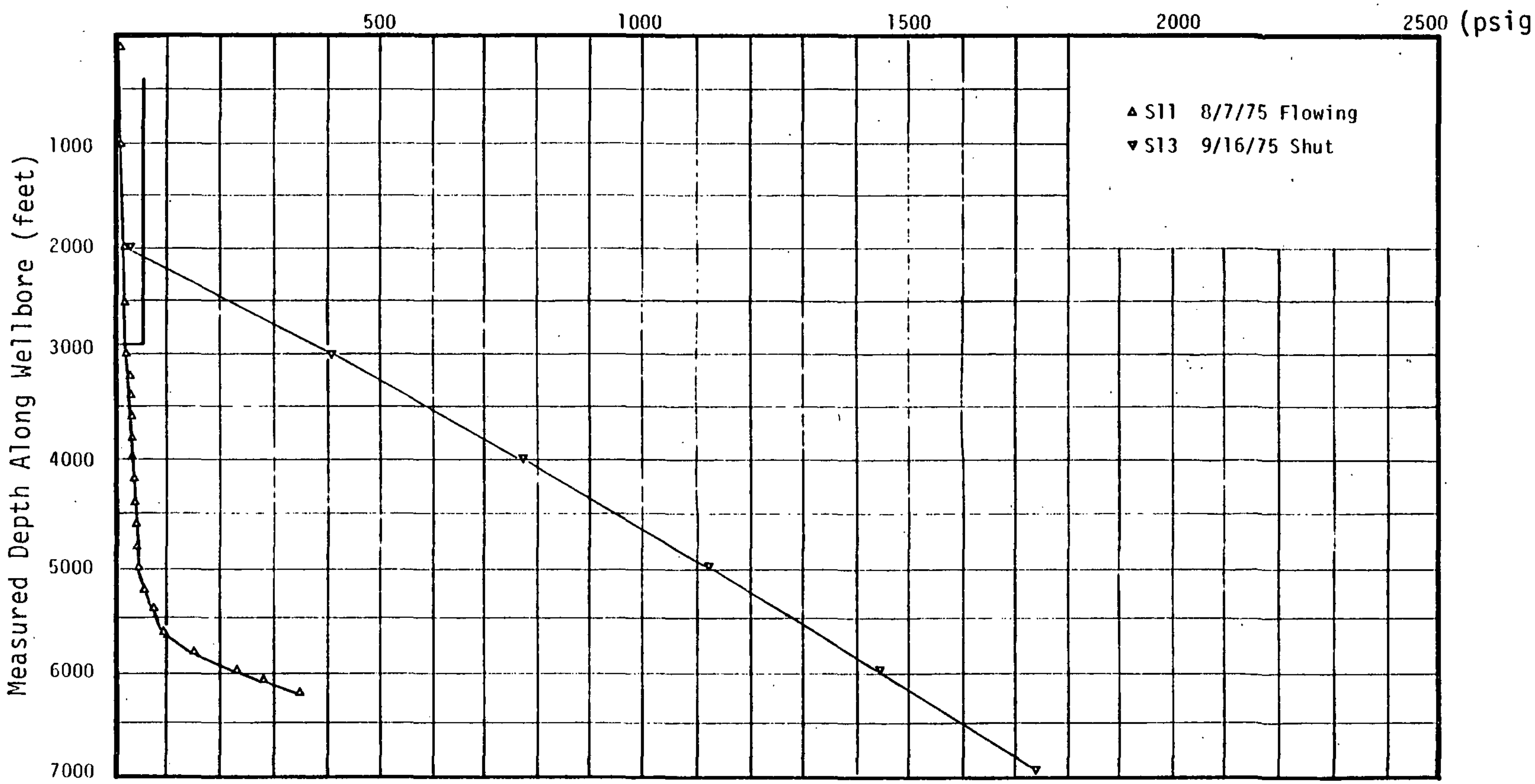

Figure 3.26. B-16 Pressures

those obtained in the completed well (Figure 3.26). Pressure at 2169 ft measured in survey S1 is only 50 psi above that given by survey S11; also pressure surveys S2 - S7 show transient decay from a pressure value 380 psi above that obtained from S11. Thus given the disturbance caused by drilling, there is no significant difference between the pressures recorded during drilling and those measured in the completed well. The temperature surveys S1 - S7 contain some important information; temperature at 2580 ft exceeds 370°F. The stable temperature profile S21, does not, however, reflect the reservoir temperatures (measured in surveys S1 - S7) in the cased section of the well. That temperatures in the cased section of a well may not reflect reservoir temperatures has been observed elsewhere (Grant [1979c]). Wells in the vapor-dominated reservoir at Kamojang, Indonesia, show linear temperature profiles within their cased sections; temperature surveys in shallow wells show that this is not the reservoir temperature. A more accurate estimate of the reservoir temperature in the interval 1000 - 2550 ft might be obtained by using the method of Roux, et al. [1979] to estimate temperature recovery.

In the completed well, injection survey S9 indicates that water is lost in the interval 5500 - 6000 ft. The warming survey S10 shows cooling at ± 3600 ft and at ± 5500 ft. Also, the flowing survey S11 indicates static fluid in the wellbore beneath approximately 5750 ft. Thus the reservoir permeability is at ± 3600 ft and at ± 5500 ft. Since the well has generally poor permeability, reservoir temperatures are given by stable temperature profile S21. Generally low temperatures (S21) imply that the reservoir fluid is compressed liquid.

3.20.2 Summary

Primary permeability at 5500 - 6000 ft (4189 - 3715 ASL), secondary permeability at 3600 ft (~ 6042 ASL). Reservoir pressure at 5500 ft (4189 ASL) is 1290 psig. Reservoir temperature

3500 - 7000 ft (6140 - 2797 ASL) near S21. Reservoir temperature 1000 - 2550 ft (8623 - 7075 ASL) obtainable by extrapolation from S2 - S7. Reservoir fluid liquid water.

3.21 Well Baca No. 17 (Redondo Creek Area)

Ground Level Elevation: 9361 ASL
Zero Point for Downhole Surveys: 9371 ASL
Drilling Data: (8/13/78 - 12/5/78)

1. Drilled to a total depth of 5791 ft (3624 ASL).
2. Due to an inability to flow, well was plugged back to 3056 ft (6308 ASL). The hole sidetracked at 3056 ft, and drilled to 6254 ft (3240 ASL).

Casing Data: bottom of 9-5/8" casing set at 3000 ft (6363 ASL); 7" slotted liner hung from 2885 ft (6473 ASL) to 6250 ft (3244 ASL)

Formations Encountered During Drilling:

1. Valles Rhyolite: 0 - 400 ft (9361 - 8961 ASL)
2. Caldera Fill: 400 - 980 ft (8961 - 8381 ASL)
3. Bandelier Tuff: 980 - 5520 ft (8381 - 3925 ASL)
4. Paliza Canyon Andesite: 5520 - 6254 ft (3925 - 3240 ASL)

3.21.1 Analysis

Due to a casing collapse, the well was plugged from 420 ft (8941 ASL) to 1485 ft (7876 ASL) and abandoned. A few downhole pressure/temperature surveys are, however, available, and are shown in Figure 3.27.

Two downhole pressure/temperature surveys were made during drilling after a major circulation loss at about 2700 ft. Both the pressure surveys S1 and S2, made 5 hours and 11 hours after stopping circulation, show identical pressures; thus the measured pressure of 485 psig at 2750 ft may be the reservoir pressure. The latter pressure value lies on the trend of Baca reservoir pressures. There was some discharge of steam during drilling, possibly indicating the presence of a shallow two-phase zone. These data, together with the steam entries encountered during the drilling of Baca Well B-4, may give some information on the fluid profile at shallow depths. There

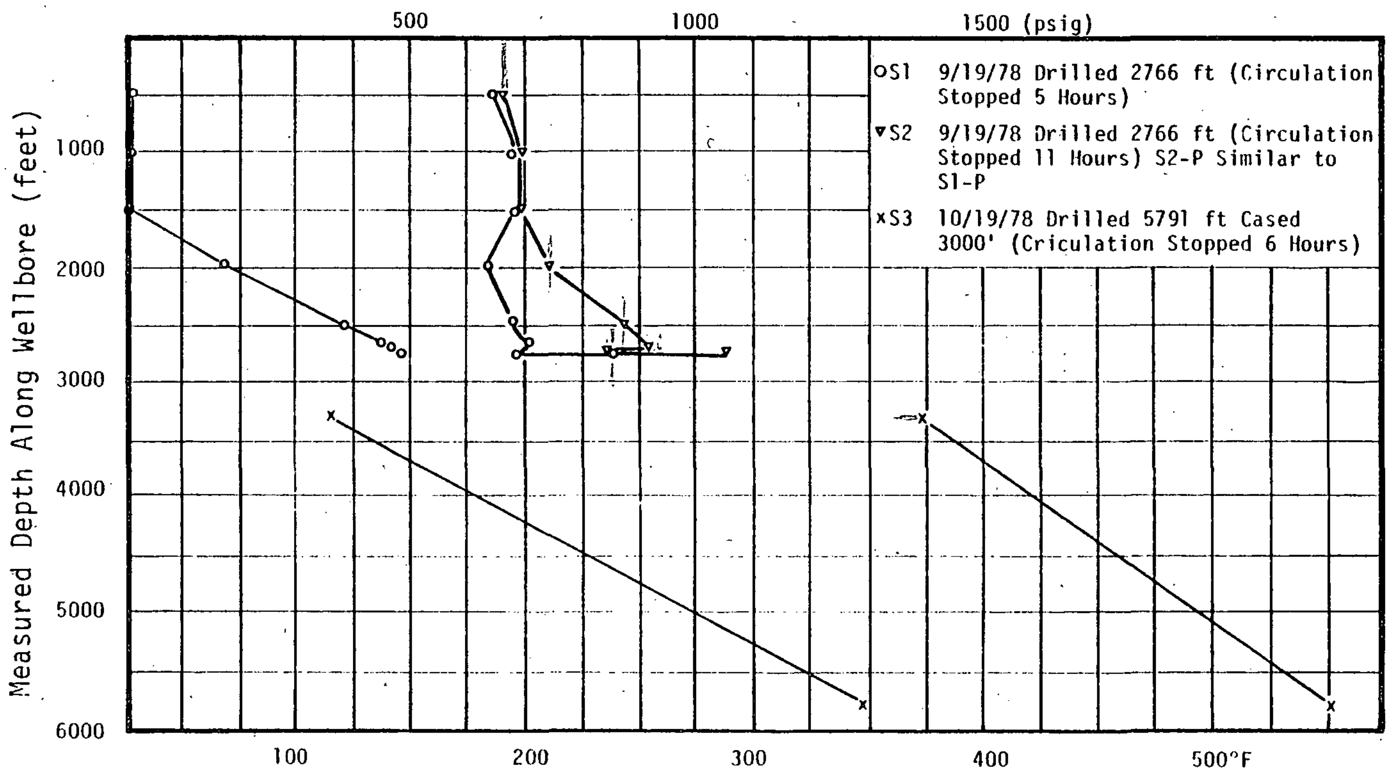

Figure 3.27. B-17 Pressures and Temperatures

is, however, no guarantee that the pressure gradient as recorded in surveys S1 and S2 represents the reservoir pressure gradient; the hole may have filled with steam if allowed to stand for sufficiently long time.

Drilling records indicate drilling breaks/fractures over the depth interval 4796 - 5510 ft, and possible steam enteries at 4796 - 4805 ft. Temperature survey S3 after well completion gives a temperature of 540°F near 6000 ft (3477 ASL).

3.21.2 Summary

Some permeability at 2750 ft (6612 ASL), and possibly at 4800 ft (4600 ASL). Reservoir pressure at 2750 ft (6612 ASL) is 485 psig.

3.22 Well Baca No. 18 (Redondo Creek Area)

Ground Level Elevation: 8733 ASL
Zero Point for Downhole Surveys: + 8748 ASL
Drilling Data: (12/16/78 - 3/16/79)

1. Drilled well to a depth of 4597 ft. Drill pipe and fishing tools stuck in hole. Hole plugged back to 3100 ft.
2. Hold sidetracked at 2720 ft, and drilled 46 ft. Lost bit in hole. Hole cemented up to 2404 ft.
3. Hole sidetracked at 2410 ft (6344 ASL) and drilled to a total depth of 5250 ft (3616 ASL)

Casing Data: bottom of 9-5/8" casing set at 2018 ft (6728 ASL); alternate joints of 7" blank and slotted casing from 1853 ft (6890 ASL) to 5240 ft (3626 ASL)

Formations Encountered During Drilling:

1. Caldera Fill: 0 - 520 ft (8733 - 8213 ASL)
2. Bandelier Tuff: 520 - 5100 ft (8213 - 3762 ASL)
3. Paliza Canyon Andesite: below 5100 ft.

3.22.1 Analysis

The downhole temperature and pressure surveys are shown in Figures 3.28 and 3.29 respectively. Pressure survey S1-P (Figure 3.29) was taken on 3/21/79 some 5 days after an injection test; the

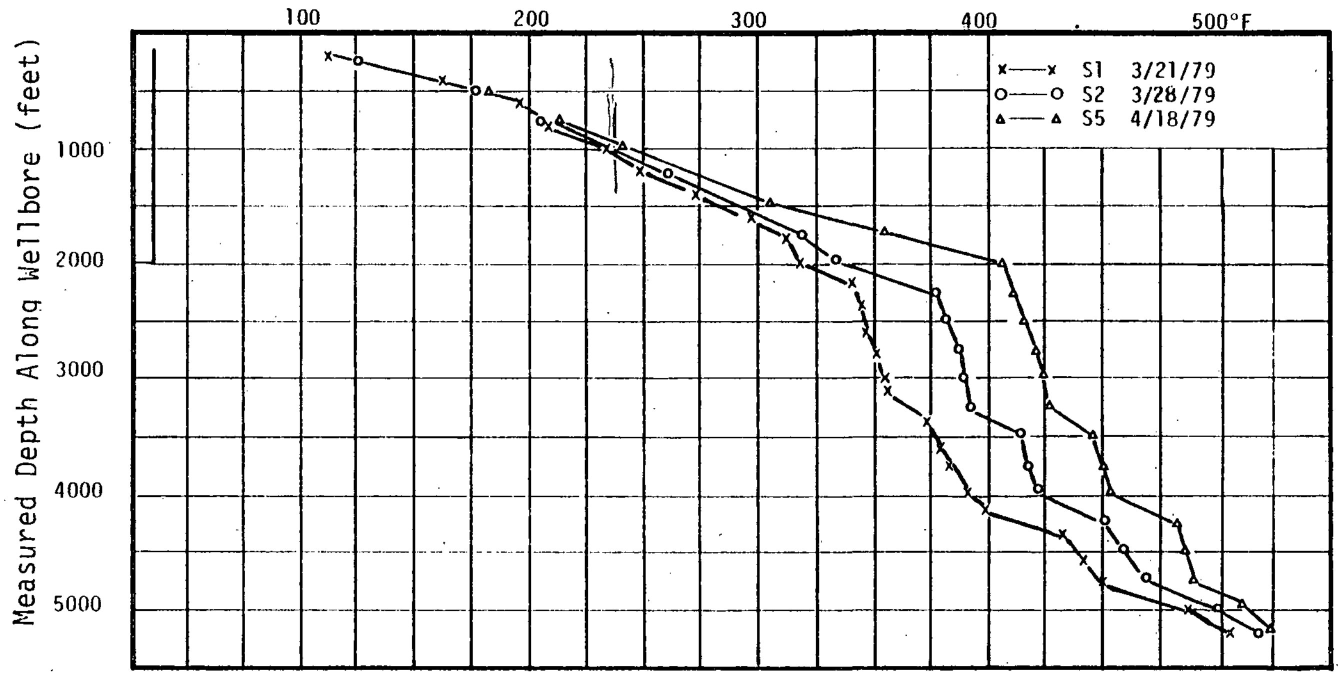

Figure 3.28. B-18 Temperature

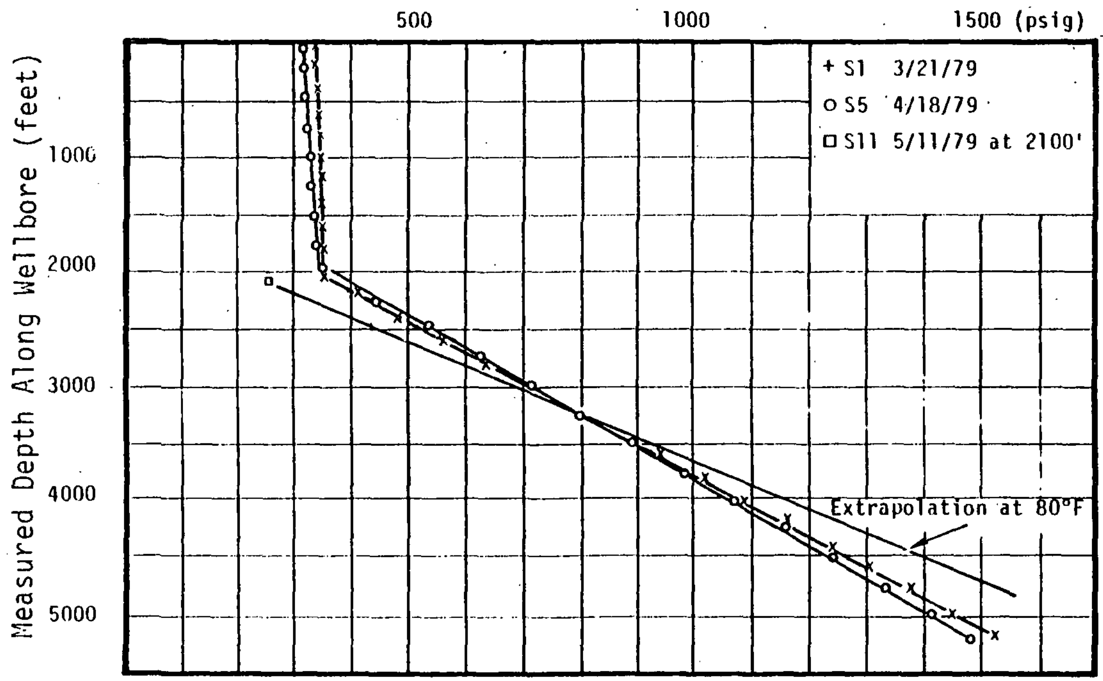

Figure 3.29. B-18 Pressures

associated temperature run S1-T is shown in Figure 3.28. Pressure profile S5 (Figure 3.29) was recorded 28 days later on 4/18/79; note that the well is now warmer (S5-T, Figure 3.28). Pressure surveys S1 and S5 coincide around 3000 - 3500 ft. The higher temperature and lower density of the water in the well during S5 implies that a lesser pressure gradient must be measured. At the well's principal feed the pressure should be the same in the two surveys; elsewhere in the well the pressure is governed by the varying hydrostatic head.

Pressures measured during warmup pivot about the "permeable level" of a well. To properly define such a pivot, we require more then two measurements. Fortunately another pressure gradient can be inferred from the results of injection testing (Figure 3.30). At the end of two days of cold water injection, the pressure at 2100 ft rapidly stabilized at about 350 psig. With p = 350 psig at 2100 ft and assuming that the temperature of the injected water is 80°F, it is possible to extrapolate pressures deeper in the well (Figure 3.29). A nice pivot is formed about 3250 ft. During shutin, in the absence of any residual pressure transient effects, pressure is constant at 3250 ft, and varies at other depths as the well continues to warm up. The median point of permeability in B-18 is thus located at approximately 3250 ft. The stable pressure at 3250 ft is 800 psig. The highest temperature (presumably reservoir temperature) recorded at 3250 ft is about 426°F; saturation pressure for pure water at this temperature is approximately 330 psia. The saturation pressure is thus some 480 psi lower than the recorded pressure at 3250 ft; this indicates that in the absence of gas contents which substantially exceed those reported from other Baca wells, the reservoir fluid feeding B-18 is compressed liquid. The difference between reservoir pressure (as defined by measurements on all Baca wells) and B-18 saturation pressures increases with depth; this confirms that B-18 penetrates only compressed liquid.

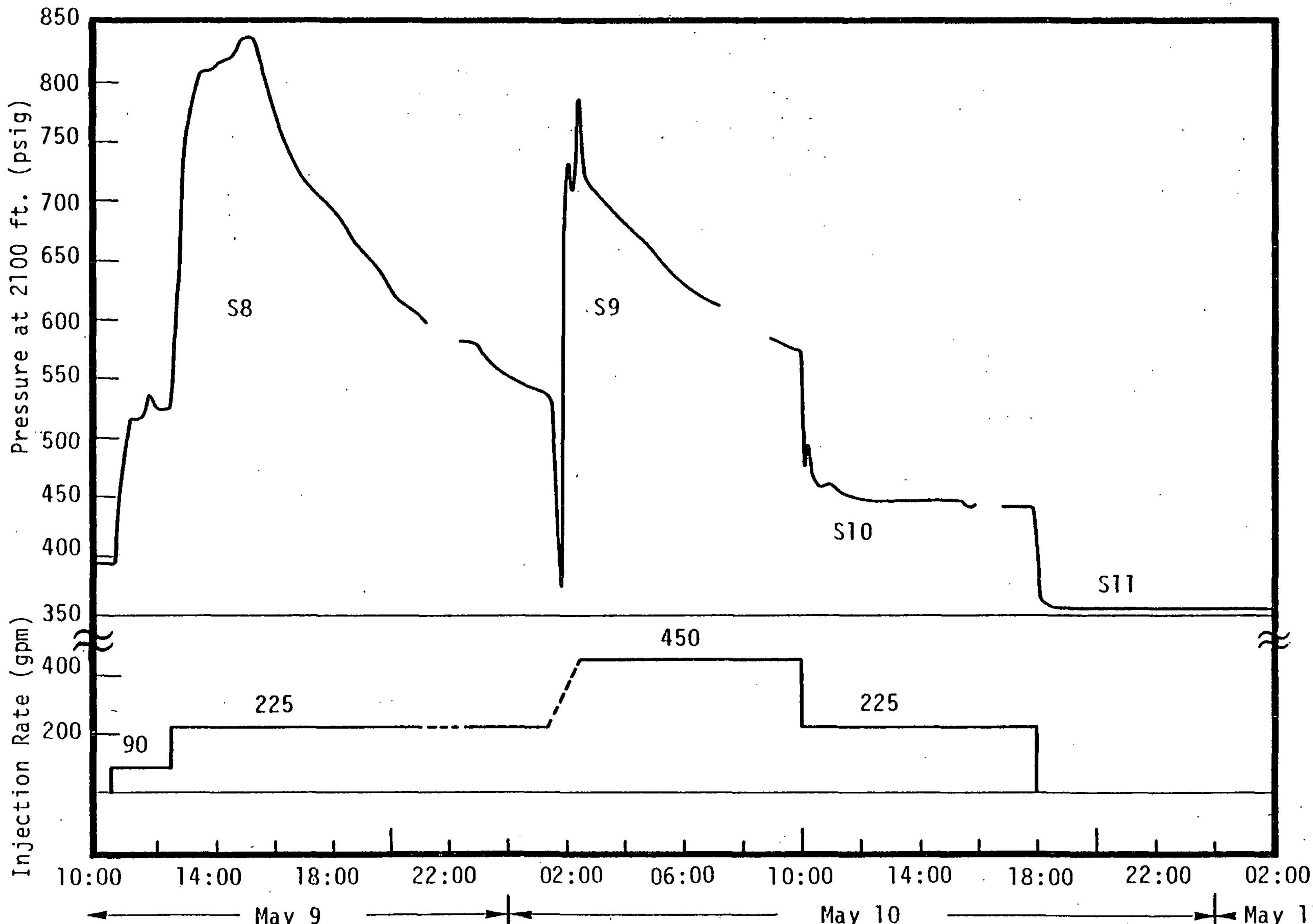

Figure 3.30. B-18 Injection Pressures at 2100 feet (May 9, 1979 to May 11, 1979)

The successive temperature surveys S1-S5 (Figure 3.28) show similar profiles, with no points heating up markedly faster or slower. There is also absence of any obvious pattern of fluid circulation in the wellbore; this implies that the well is heating conductively and has poor permeability. It is, therefore, likely that the temperature profile S5 approximates the reservoir temperatures.

During shutin, the wellhead pressure (WHP) in B-18 remains stable at about 340 psig with the water level just below the casing shoe (say at 2050 ft); this indicates the presence of some minor permeability at approximately 2050 ft. Apparently when the well is shutin, gas accumulates in the casing and drives down the water level; presence of permeability at 2050 ft, however, prevents the water level being driven beneath this depth. Figure 3.31 shows several pressure profiles for a shutin well wherein gas is accumulating above a continually depressing water level. Reservoir pressure is assumed to be close to the hydrostatic gradient bc; abc is the first possible pressure profile. Accumulation of some additional gas at the top of the well produces the pressure profile dec. Let us now suppose that there is a permeable zone between the depths e and g. The pressure profile gfc cannot exist in the stable shutin state of the well since gas would be injected into the permeable zone between e and g.

All of the pressure surveys for B-18 show a stable WHP of either about 340 psig, or a much smaller one (i.e., abc). The well was pressurized (by air injection) several times to initiate discharge. From 780 psig at 12:00 hours on 3/12/79, WHP fell to 500 psig in one hour; also from 650 psig at 19:30 hours on 3/12/79, WHP declined to 550 psig by 8:00 hours the next day. The WHP was raised to 600 psig at 8:00 hours on 3/16/79; it fell to 338 psig by 10:00 hours on 3/20/79 and remained at 334-340 psig for the next 15 days.

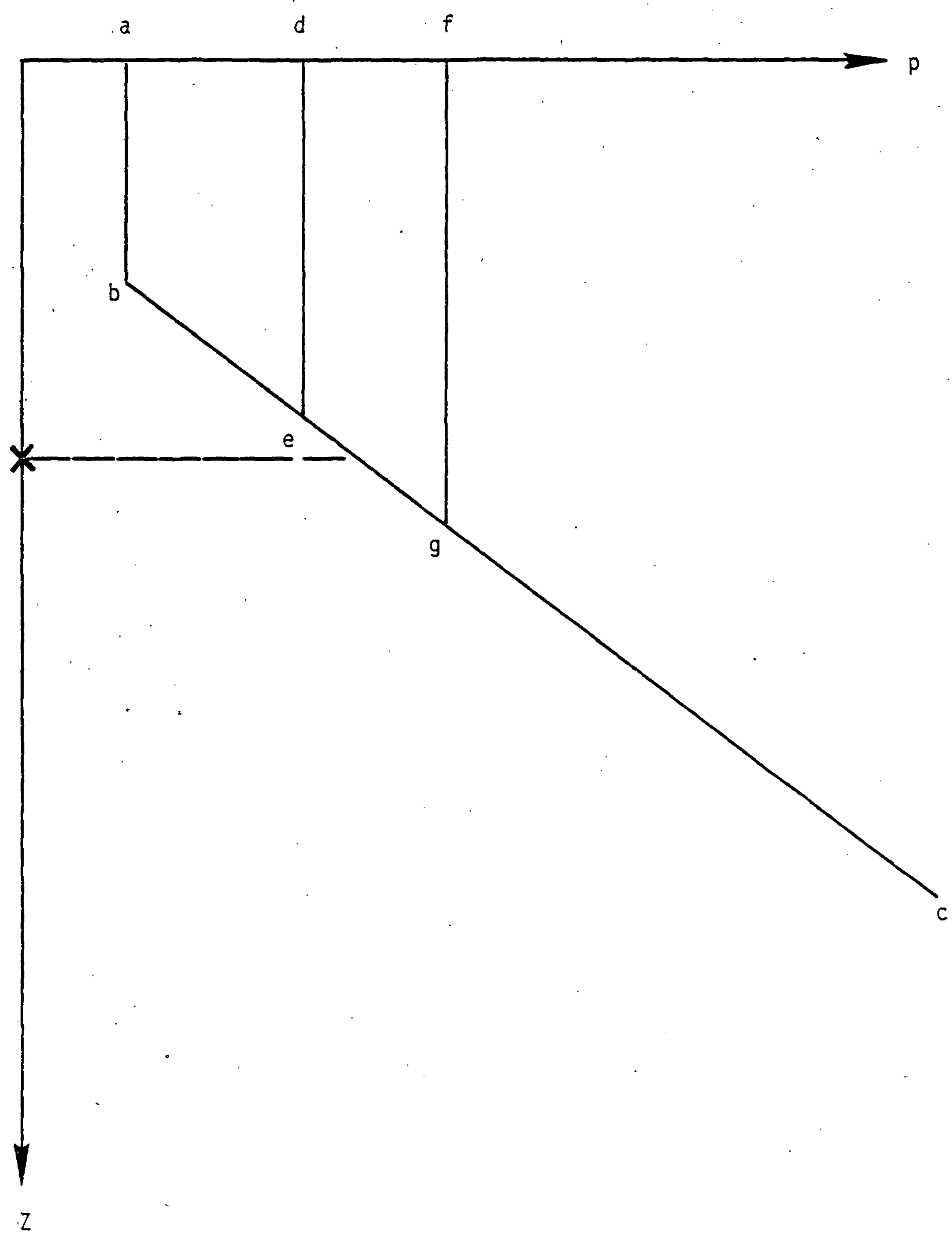

Figure 3.31. Pressure Profiles in a Well with a Gas Cap (see text for discussion).

Apparently, it takes at least several hours (maybe even days) for the permeable zone at 2050 ft to accept enough gas to lower the WHP to 340 psig; this indicates the presence of only minor permeability at 2050 ft. Note that the preceding discussion does not imply that the reservoir fluid at 2050 ft is gas.

Preliminary flow data indicate that B-18 discharges a fluid of relatively high enthalpy. This does not necessarily indicate two-phase conditions in the reservoir. With low formation permeability, in formation flashing can produce a discharge of elevated enthalpy.

Figure 3.30 shows the pressures measured at 2100 feet during cold water injection at various rates from 10:30 hours on 5/9/79 to 02:00 hours on 5/11/79. Each pressure reading was made with two different gauges, and good agreement between the two sets of measurements was always obtained. It is immediately apparent from Figure 3.30 that some abnormal effect is present. After the increase in injection rate from 90 gpm to 225 gpm (12:30 hours on 5/9/79) and from 225 gpm to 450 gpm (01:30 - 02:30 hours on 5/10/79), the pressure rapidly rises, and then slowly falls. After the drop in injection rate from 450 gpm to 225 gpm (10:00 hours on 5/10/79) and from 225 gpm to 0 gpm (18:00 hours on 5/10/79), the pressure rapidly falls and attains a stable value in a relatively short time.

The rapid stabilizing of the pressure fall off at shutin is unusual; similar behavior has often been observed in wells in New Zealand. The wells in New Zealand, however, also usually exhibit a similar rapid stabilization of pressure in response to increases in flow rate.

There are several possible explanations for the rise and subsequent fall in pressure which accompany increases in injection rate for B-18:

(i) interference effects by an adjacent well,
(ii) changes in the water density in the well,
(iii) fall in reservoir pressure caused by injecting cold water into two-phase fluid,
(iv) change in permeability or skin caused by injection.

We shall next examine each of these explanations in turn.

The required interference at B-18 would have to exceed 300 psi. Since there were no nearby wells discharging, this large pressure interference appears to be unlikely.

Although changes in fluid column density can cause anomalies in injection pressure transients (Grant, et al. [1979]), such density changes over the entire length of the open hole (~ 3000 ft) could give at most at 200 psi change; this is insufficient.

A fall in reservoir pressure of a few bars, due to cold water injection into a two-phase system, has been seen at Broadlands, New Zealand; and is routinely observed after cold water injection in wells in vapor-dominated reservoirs. However, since the stable pressure in B-18 attained at shutin is close to the initial pressure it would appear that a fall of 300 psi in reservoir pressure has not taken place.

A change in permeability and/or skin, is quite possible. The well was discharged only briefly (3/12/79, 3/13/79 and 4/24/79) prior to the injection test. It is thus probable that fractures were still laden with cuttings at the time of the injection test; injection fluids presumably washed these cuttings away from the wellbore. (Note that the permeable zone at 2700 ft may have accepted circulating fluid from drilling beneath this depth.) It is common practice in Iceland to "stimulate" a well by injection at maximum available rates, which usually raises the well's injectivity to a value equal to that implied by circulation losses. Strictly speaking, injection does not cause well stimulation in the usual sense; it merely accomplishes an effective washing of the hole. In a more productive well, the same effect will be achieved by the first discharge. Similar improvement in permeability with injection is observed in the Philippines (Whittome [1979]). On this interpretation, the two falloffs (S10 and S11 in Figure 3.30) represent "real" pressure response to changes in injection rate; and the rest of the record merely reflects the washing of the hole.

The stable pressure for an injection rate of 225 gpm is 442 psig; also the stable shutin pressure is approximately 350 psig. Thus the well injectivity is 225/(442 - 350) ≈ 2 gpm/psi. The low value of injectivity implies that the well has permeability sufficiently low such that the well may not sustain continued discharge.

3.22.2 Summary

Reservoir temperature is given approximately by stable temperature profile S5. Permeability is poor, and ill defined. The median point of permeability is 3250 ft (5543 ASL). Reservoir pressure at 3250 ft is 800 psig.

3.23 Well Baca No. 19 (Redondo Creek Area)

Ground Level Elevation: 9119 ASL
Zero Point for Downhole Surveys: 9131 ASL
Total Depth Drilled: (9/24/79 - 11/3/79) 5610 ft (3655 ASL)
Casing Data: bottom of 9-5/8" casing set at 2480 ft (6647 ASL); 7" blank and perforated liner hung from 2328 ft (6795 ASL) to 5585 ft (3678 ASL)
Formations Encountered During Drilling:

1. Caldera Fill: 0 - 220 ft (9119 - 8899 ASL)
2. Bandelier Tuff: 220 - 5350 ft (8899 - 3898 ASL)
3. Paliza Canyon Andesite: below 5350 ft.

3.23.1 Analysis

Baca-19 was deviation drilled from a site close to Well B-15. Downhole pressure/temperature profiles for B-19 are, however, strikingly different from those for B-15. Drilling records for B-19 indicate partial or complete circulation losses over the depth interval 3200 - 4033 ft; approximately 175 bbl/hr of water were gained when drilling at 4700 - 5610 ft.

A considerable number of downhole pressure/temperature surveys, and flow measurements have been made in B-19. Two-injection tests (a "low rate" and a "high rate" test) were carried out in December 1979. A spinner survey during the "high rate test" showed that 20 percent of the fluid was lost at 3500 - 3700 ft, and 80 percent lost at 5000 - 5200 ft. Most of the fluid loss at 5000 - 5200 ft was recorded in a 10 ft interval at 5170 - 5180 ft (Atkinson [1980a]).

The temperature surveys during well warmup after cold water injection, Figures 3.32 and 3.33, strongly suggest interzonal flow (downflow) between a zone at ± 3000 ft and the one at ± 5000 ft. Temperature measurements at 4500 ft, Figures 3.34 and 3.35, during and after each injection test show that temperature falls during injection, and then rises rapidly as soon as the injection is stopped. This again suggests that interzonal flow occurs in the well immediately after injection stops; hot water enters the well, mixes with and replaces the cold water.

Figures 3.36 and 3.37 show the pressure profiles after the two injection tests. Pressure profiles after high rate injection test, Figure 3.37, form a nice pivot at 4000 ft; the reservoir pressure at 4000 ft is 955 psig. The pressure fall off after injection, Figure 3.38, indicates that after about 5 hours the

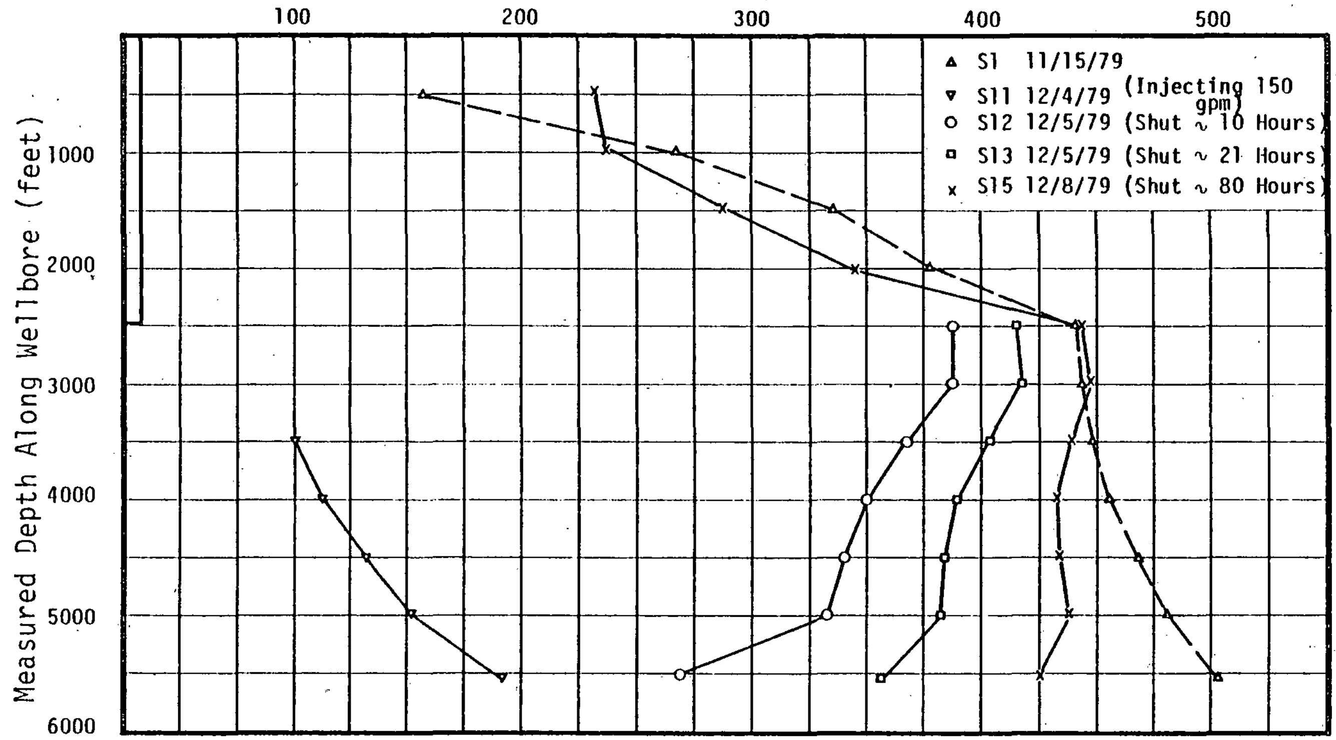

Figure 3.32. B-19 Temperature Surveys Prior to, During and After Low Rate Injection Test (50 gpm from 13:00 Hours on 12/3/79 to 2:19 Hours on 12/4/79; 150 gpm from 2:19 Hours 12/4/79 to 00:45 Hours on 12/5/79).

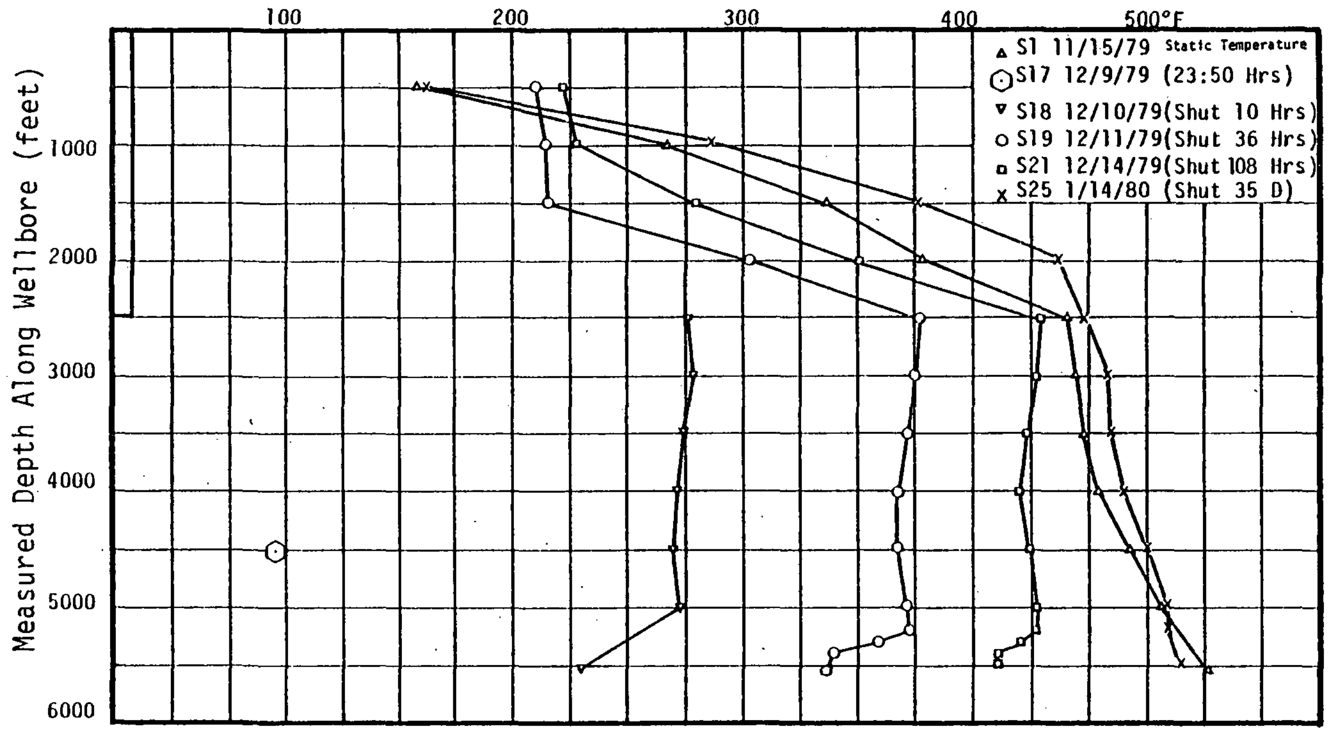

Figure 3.33. B-19 Temperature Surveys Following High Rate Injection Test (400 gpm from 10:00 Hours on 12/8/79 to 11:25 Hours on 12/8/79; 380 gpm from 11:03 Hours on 12/9/79 to 22:00 Hours on 12/9/79; 680 gpm from 22:00 Hours on 12/9/79 to 23:35 Hours on 12/9/79).

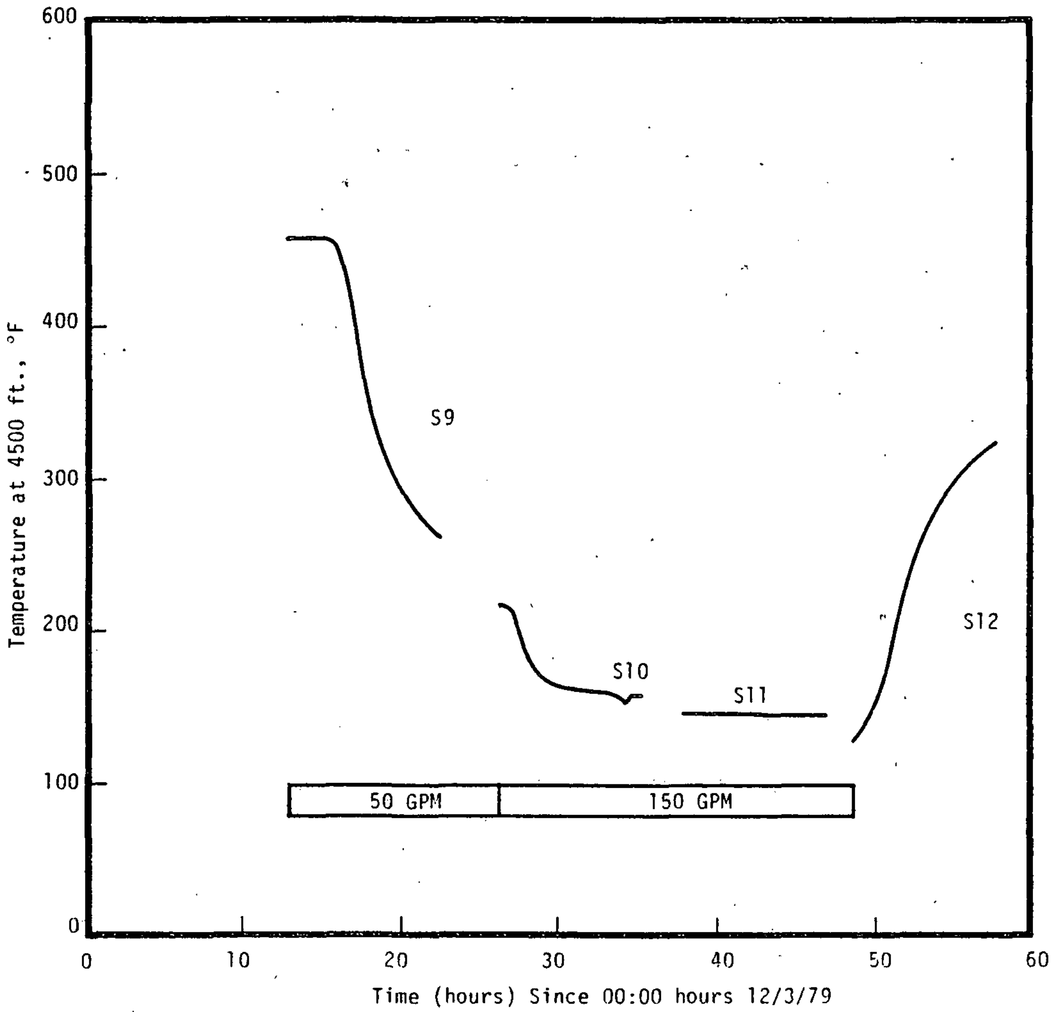

Figure 3.34. Baca 19 Temperature Surveys During Low Rate Injection Test. (from Atkinson [1980a]).

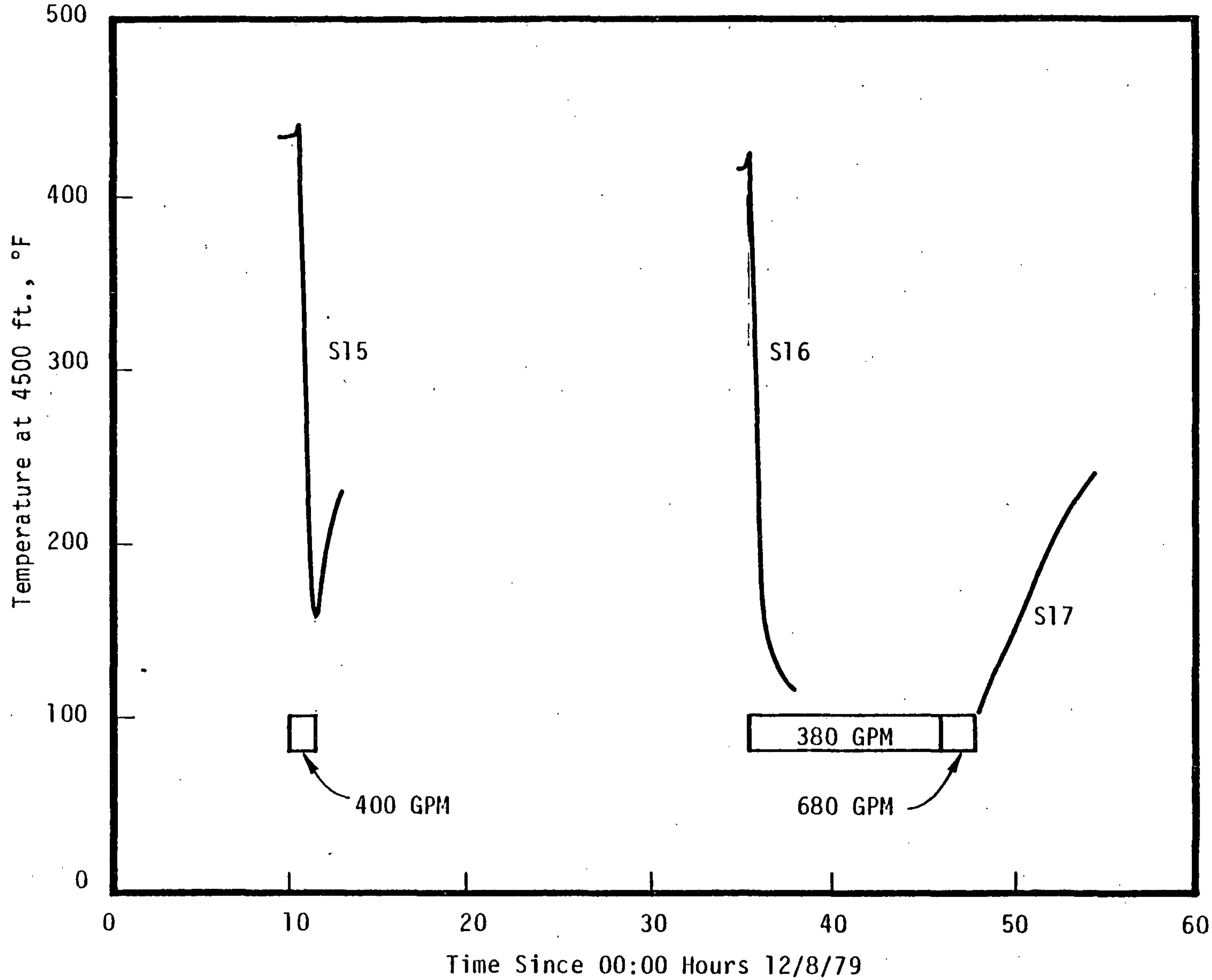

Figure 3.35. Baca 19 Temperature Surveys During High Rate Injection Test. (from Atkinson [1980a]).

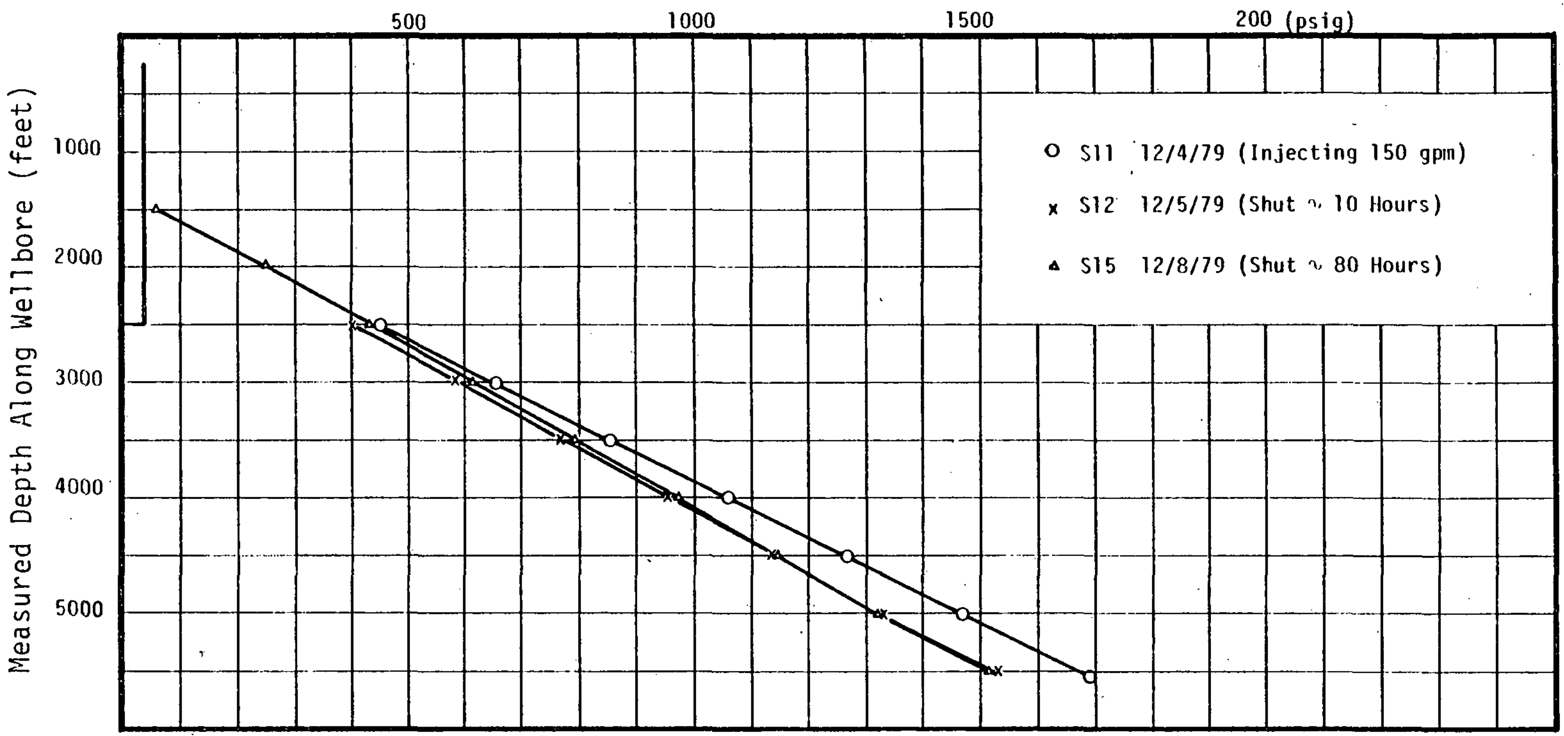

Figure 3.36. B-19 Pressures During and After Low-Rate Injection.

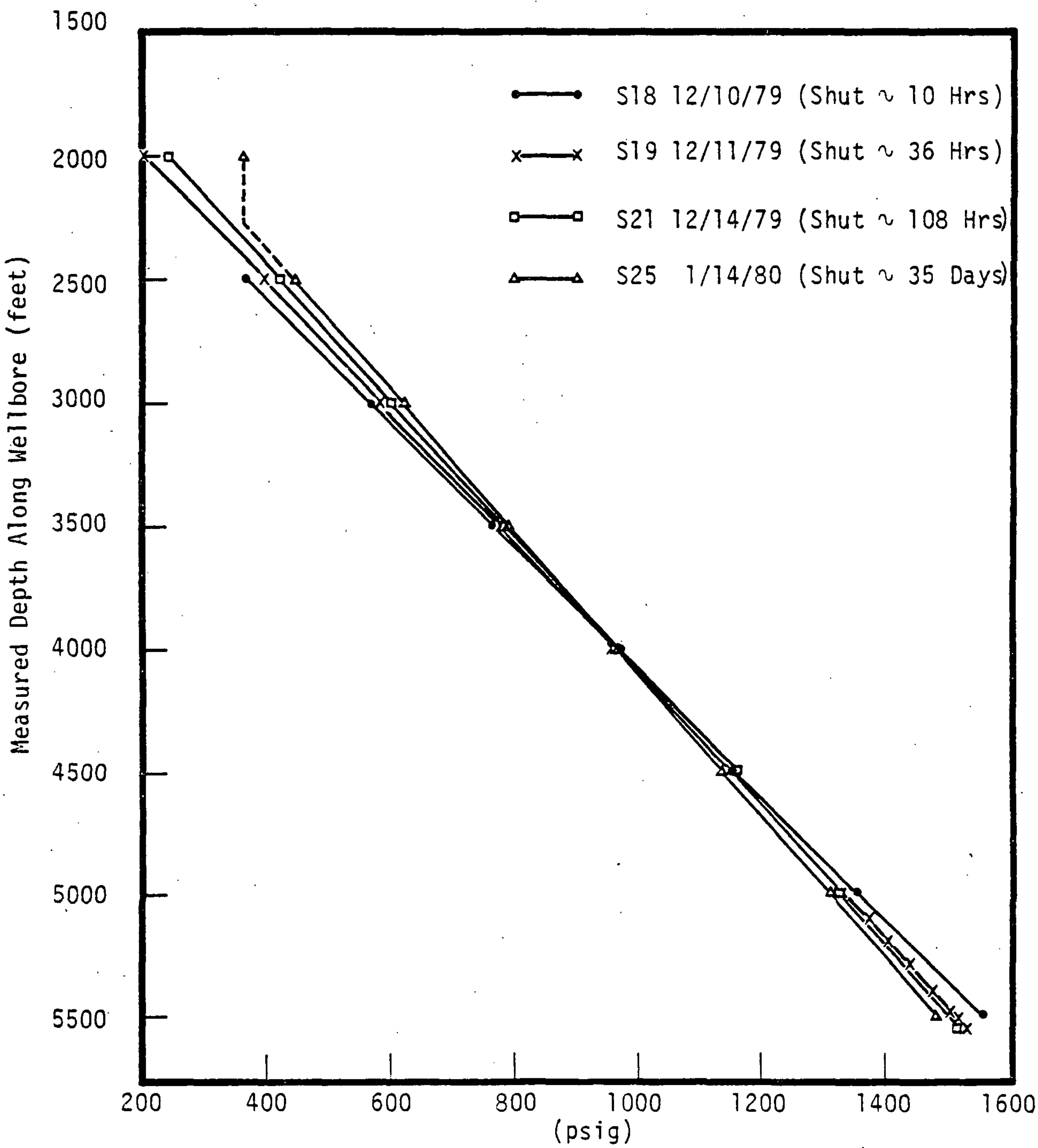

Figure 3.37. B-19 Pressures After High-Rate Injection.

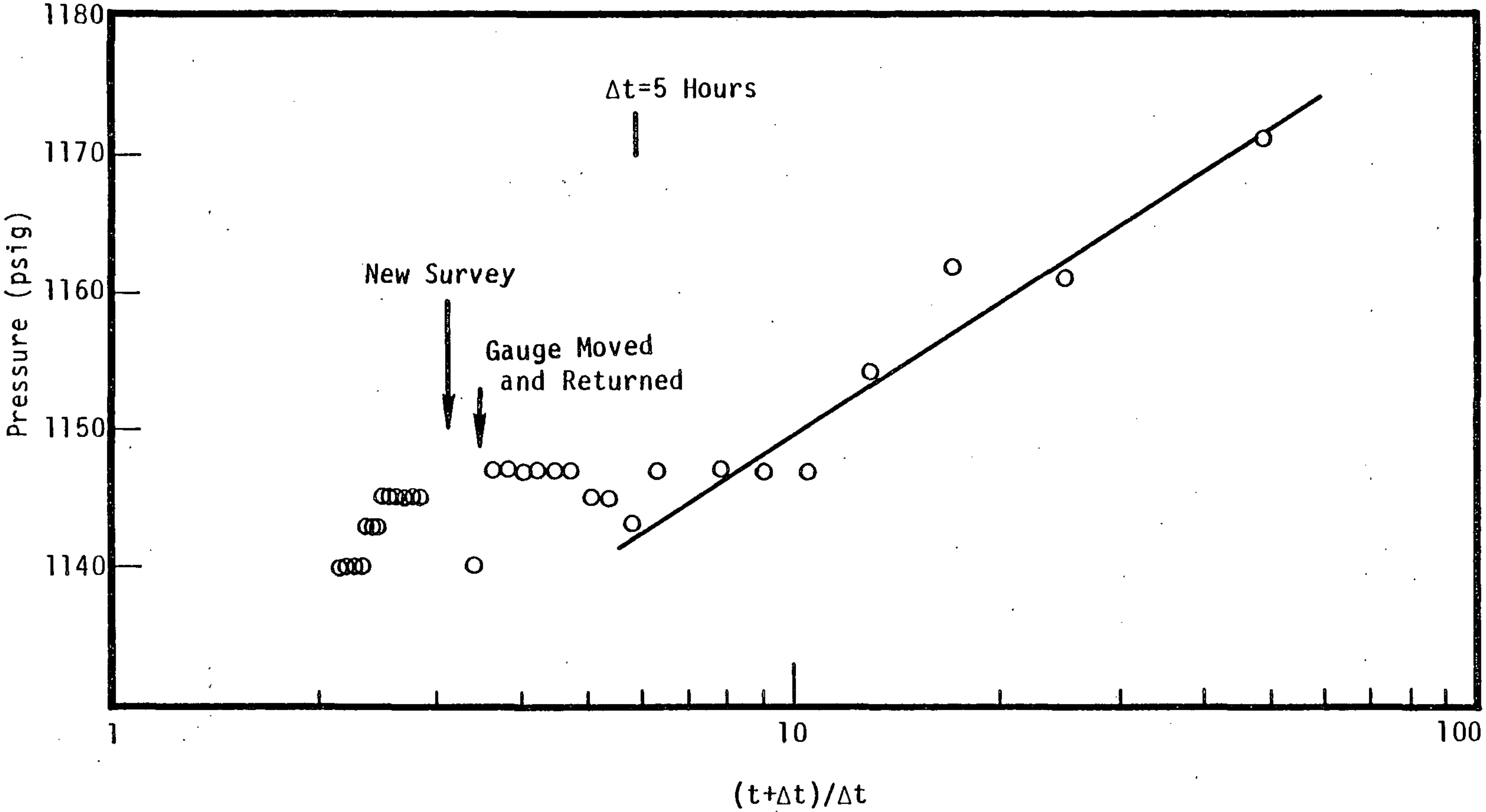

Figure 3.38. B-19 Pressure Falloff at 4500 ft After Low-Rate Injection.

pressure transient effects become negligible such that a valid pivot can be defined by using pressure surveys taken after this time. Figure 3.38 also shows oscillatory pressure behavior after injection; this is normal in wells with interzonal flow.

Baca-19 exhibits a cycling behavior on discharge; this implies the presence of two feed zones supplying fluids of different enthalpies. The latter observation is consistent with the results of the injection tests. Flowing surveys show two distinct types of pressure profiles in the well (Atkinson [1980a]). For part of the cycle a continuous liquid column exists in the well up to about 2800 ft. During the rest of the cycle (and also during periods of steady flow), boiling fluid extends below 5000 ft. Although the discharge enthalpy has not been measured, there are indications that it (discharge enthalpy) may be quite high for part of the cycle (Atkinson [1980a]).

The cycling behavior of the well can be explained by assuming that the upper permeable zone (at ± 3000 ft) contains liquid water at about 450°F, and that the lower zone (at ± 5000 ft) contains possibly two-phase fluid at a temperature which substantially exceeds the recorded value of ± 480°F. (Reservoir temperature beneath 3000 ft is persistently obscured by the downflow of cold water from the upper zone.) The two phases of the cycle (i.e., low WHP and low flow rate, and high WHP and high flow rate) correspond to discharges from the two zones. During the low WHP phase of the cycle, liquid water enters the well at upper zone. Most of the liquid water flows up the well; however, a fraction may descend the well and be injected into a lower zone. This phase of the cycle is characterized by a decrease in flow from the upper zone, and the pressure recovery of the lower zone. When the lower zone has sufficiently recovered, the wellbore unloads and is then occupied by low density two-phase fluid discharging from the lower zone. During this phase of the cycle, the upper zone may accept fluid. The cycle is thus caused by the discharge of high temperature fluid from the lower zone being repeatedly quenched by cooler water from the upper zone. If the well discharge was measured with a separator, so that mass flow and enthalpy history over the cycle were defined, this would enable us to validate, invalidate or refine this model. It would also help determine the enthalpy of the discharge from the lower zone.

When the well is standing shut, a downflow of water occurs from the upper zone at ± 3000 ft to the lower zone at ± 5000 ft. If the upper zone were two-phase, then both liquid and vapor phase would enter the well. The steam in the vapor phase would bubble up the wellbore and condense leaving free incondensable gas. A wellhead pressure would rapidly buildup as gas accumulated in the casing. Since the latter does not appear to occur, we conclude that the upper zone contains liquid water.

Any successful interpretation of downhole data must be able to explain the contrasting stable temperature profiles in B-15 and B-19. Figure 3.39 shows the stable temperature profiles in B-15 and B-19, and the explanation implied by the preceding downhole data analyses. Both wells are influenced by interzonal flow - up B-15 and down B-19. The only reservoir temperature measured with confidence is that at the upper zone of B-19 (temperature ~ 450°F at 3000 ft). The lower zone of B-15 is continuously discharging whereas at the lower zone of B-19 injection of water flowing down the well takes place. Both the lower zones are interpreted as two-phase with a temperature in the vicinity of 575°F (allowing some gas content).

The upper zone of B-15 is being heated by the injection of boiling fluid; since this zone is interpreted as two-phase, reservoir temperature here must be the saturation temperature

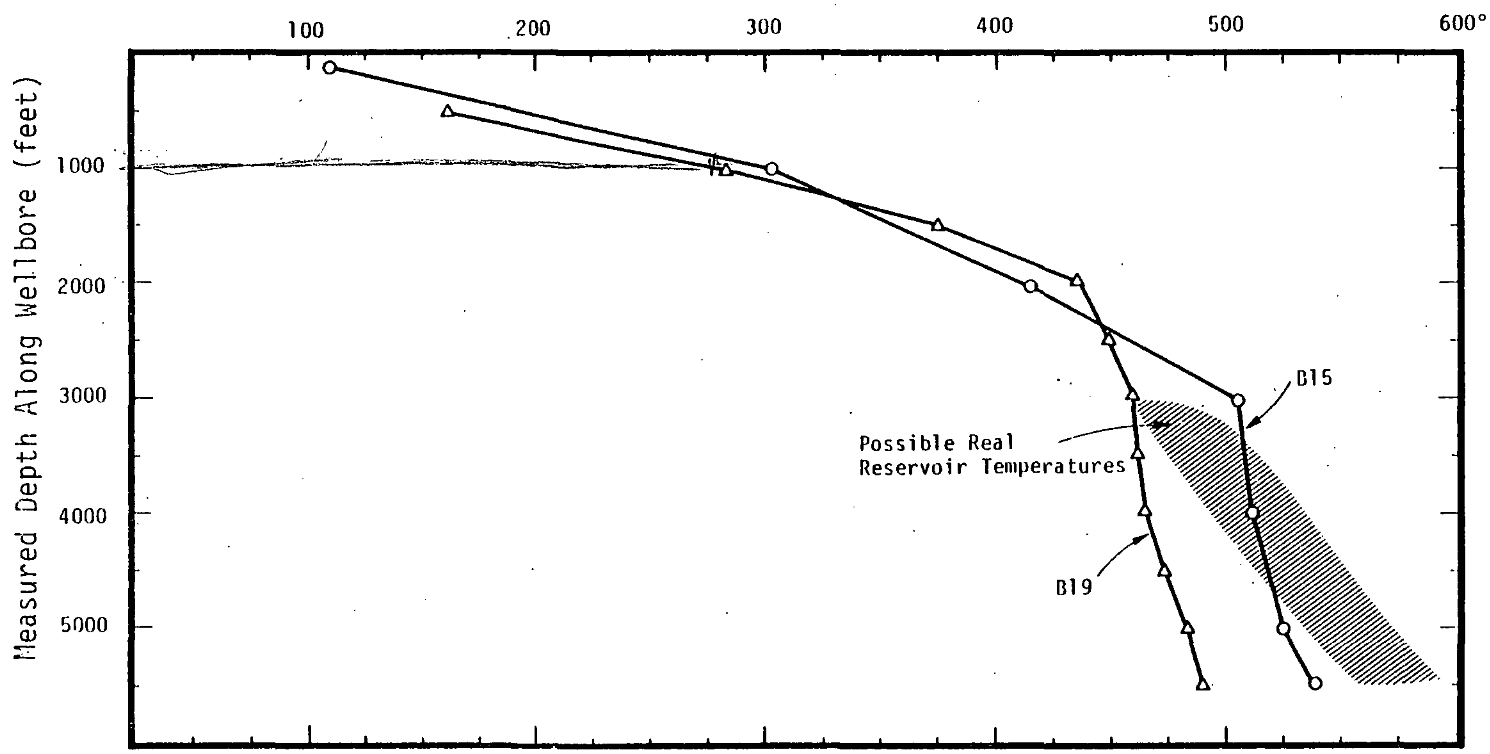

Figure 3.39. B-15 and B-19 Temperatures

corresponding to the actual reservoir pressure (note that the actual reservoir pressure is less than the pressure in the wellbore). Baca-19 has, however, liquid at ± 3000 ft; thus, it is possible that there is some genuine temperature difference between B-15 and B-19 at this depth. The shaded area in Figure 3.39 shows the range of indicated temperatures, linearly interpolated between the upper and lower zones. An interference test between B-15 (producer) and B-19 (observer) would be extremely valuable in confirming or refuting the above analysis.

3.23.2 Summary

Two permeable zones, upper near 3000 ft (6143 ASL), lower zone at about 5200 ft (3937 ASL). Upper zone liquid, lower zone hotter, perhaps two-phase. Persistent downflow in well obscures reservoir temperatures below 3000 ft (6143 ASL). Reservoir pressure at 4000 ft (5177 ASL) is 955 psig.

SECTION 4: CONCEPTUAL RESERVOIR MODEL

4.1 Introduction

Although there are indications that the Baca geothermal reservoir (e.g., see discussions of Baca wells 7 and 8 in Sections 3.11 and 3.12) extends over a large part of the Valles Caldera, the GDPP Project is restricted to the Redondo Creek area. Most of the wells drilled up to November 1979 in the project area lie along two parallel straight lines marked as cross-sections AA' and BB' in Figure 4.1. In this section the analyses for these individual wells in the Redondo Creek area will be integrated to construct the initial temperature and pressure distributions in that portion of the Baca reservoir system that corresponds to the GDPP Project. The locations of apparent permeable zones, two-phase and single-phase regions in the reservoir and the stratigraphy of the formation rocks will also be delineated.

4.2 Summary

The reservoir pressures identified from the analysis of the Baca wells in the Redondo Creek area define a line of slope 0.348 psi/ft when plotted against elevations above sea level. The initial temperature contours dome upward and an initial two-phase region is located at the crest of the dome. Two permeable zones across the the Baca reservoir may be identified from the analysis of the wells drilled to date.

4.3 Stratigraphy and Permeable Horizons

The drilling records provide the essential information for defining the stratigraphy of the geothermal field. Figures 4.2 and 4.3 show the major formations encountered during drilling. The

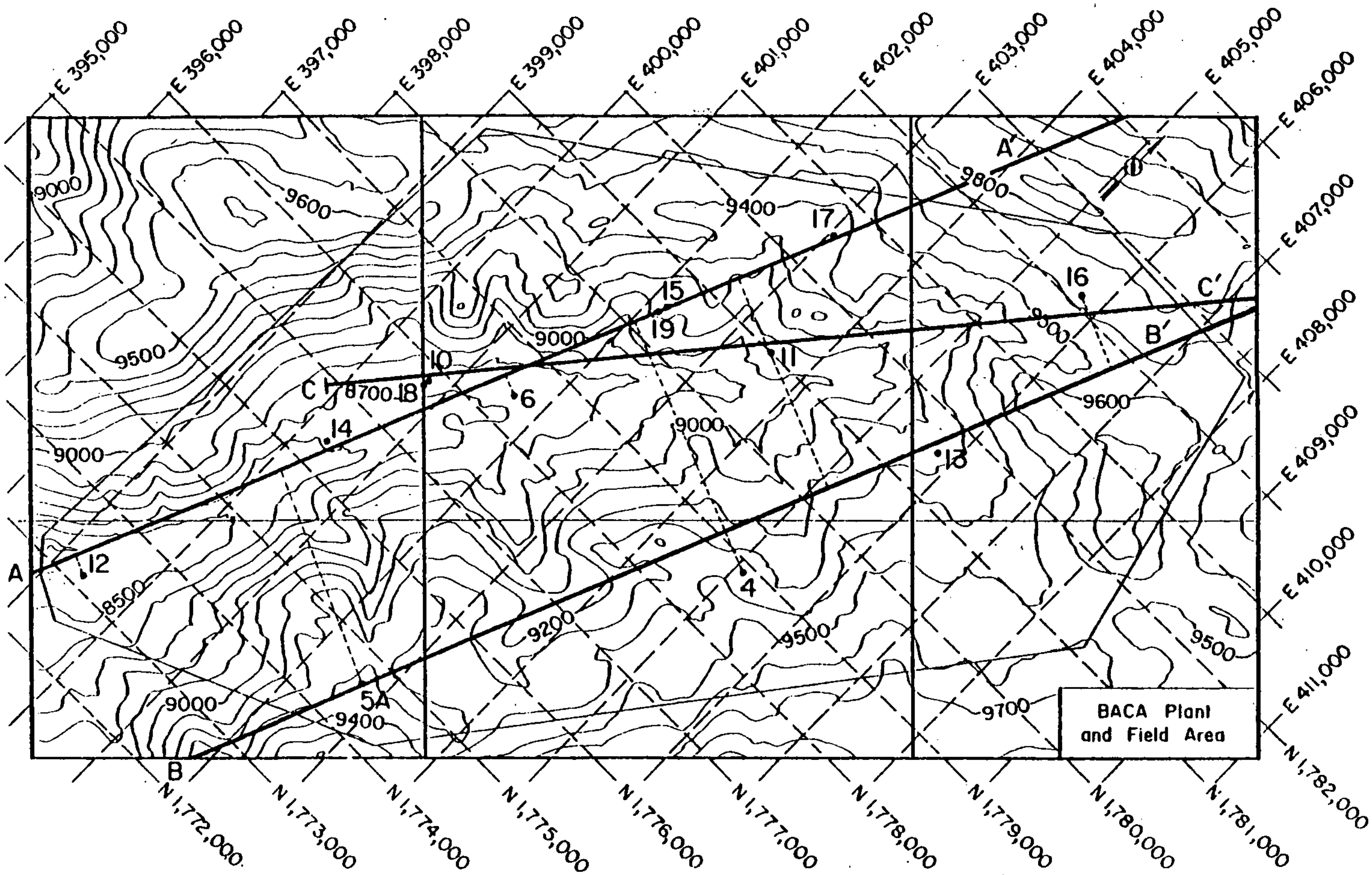

Figure 4.1. Baca Project Area and Location of Redondo Creek Area Wells (New Mexico State Plane Coordinate System).

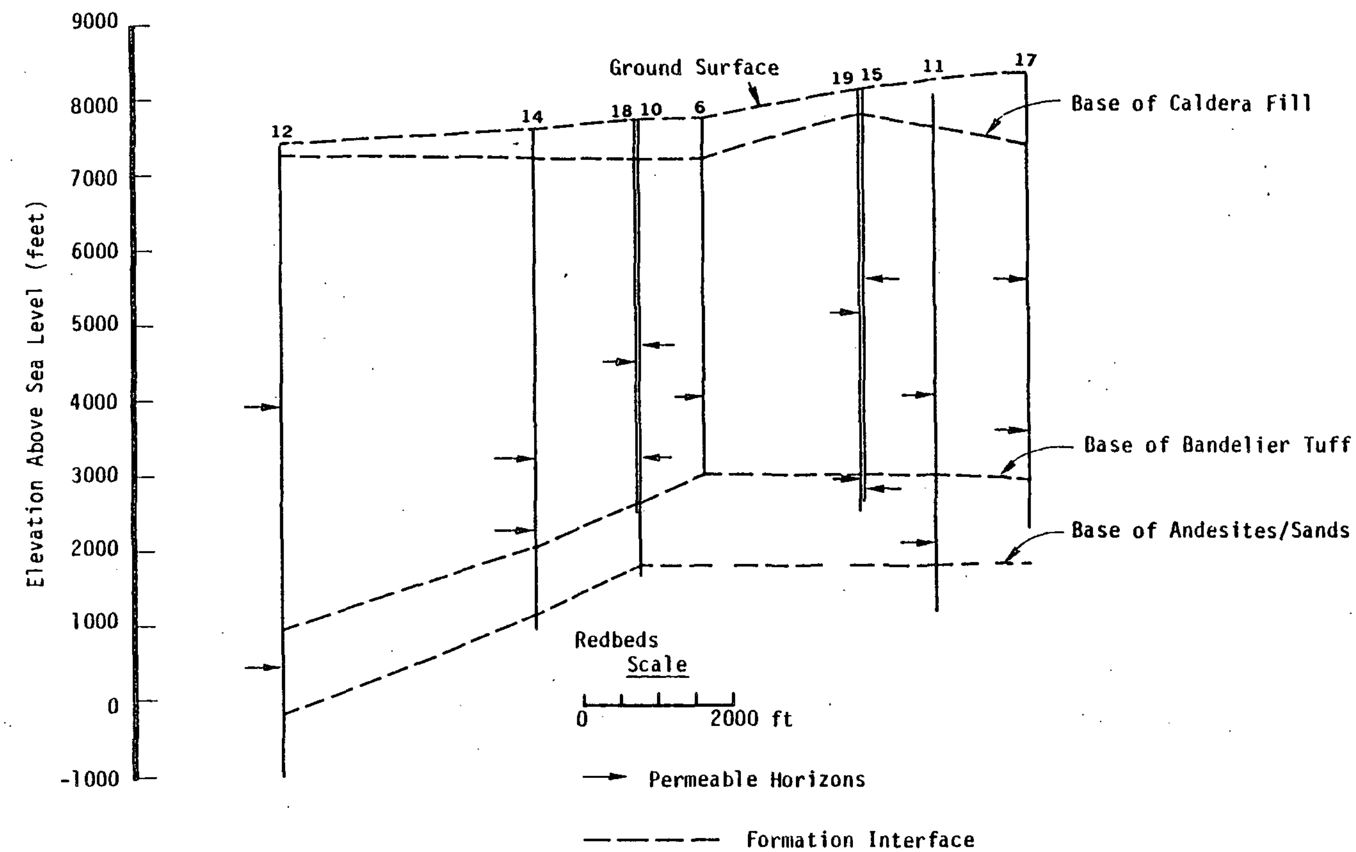

Figure 4.2. Stratigraphy and Permeable Horizons (AA')

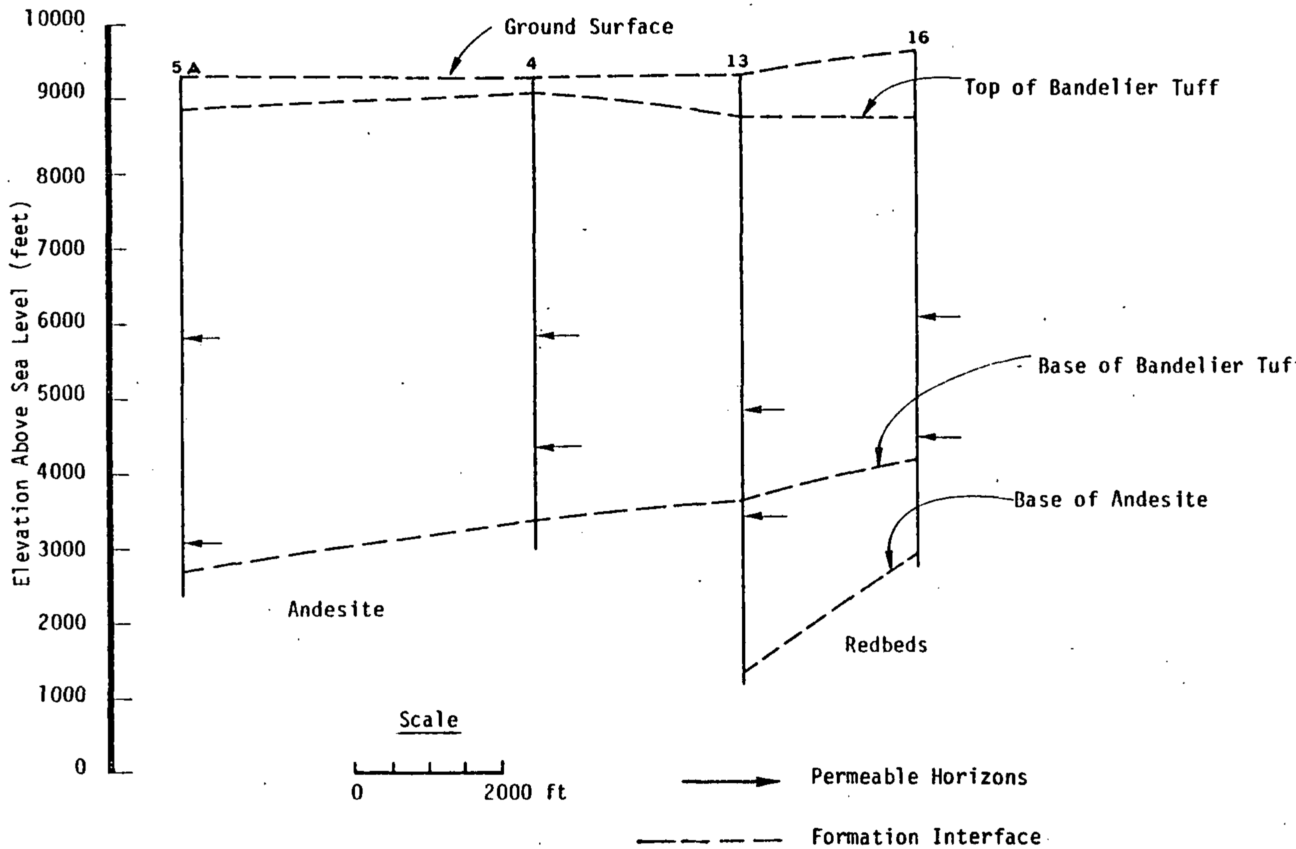

Figure 4.3. Stratigraphy and Permeable Horizons (BB')

generalized stratigraphic sequence consists of the following formations (in order of increasing depth): Caldera Fill and Valles Rhyolites, Bandelier Tuff, Paliza Canyon Andesites and Tertiary Sands, and Permian Redbeds. The Bandelier Tuff grows thicker towards the southwest.

In Section 3, we analyzed the downhole pressure/temperature surveys and flow/injection data for each well to establish the locations of permeable horizons. The permeable horizons, as deduced from downhole data, are also indicated in Figures 4.2 and 4.3. There are apparently two zones in which permeability is found. The deeper zone closely corresponds (± 500 ft) to the contact between the Bandelier Tuff and the Paliza Canyon Andesite. The upper zone (5500 ± 1000 ASL) lies within the Bandelier Tuff. It appears that the upper zone is more permeable than the lower zone. Baca Wells B-11 and B-15 produce primarily from the upper layer; B-13, however, produces substantial amounts of fluid from the lower zone.

4.4 Reservoir Pressures

The reservoir pressures identified from an analysis of the various Redondo Creek Wells (Section 3) are tabulated in Table 4.1 and are plotted against elevations above sea level (feet) in Figure 4.4. These points define a line of slope 0.348 psi/ft, which corresponds to a hydrostatic gradient at approximately 500°F. The present estimate for pressure gradient at Baca agrees closely with that previously reported by Grant [1979b]. It is also worth noting that the computed pressure gradient implies the upflow of water in the regions of reservoir where temperatures exceed 500°F.

4.5 Gas Content of Reservoir Fluids

Chemical analyses of the discharge fluids from several Baca wells (B-4, B-6, B-11 and B-13) have been presented by Hartz [1976]. Although considerable scatter is present in these data, the

Table 4.1

PRESSURE - ELEVATION DATA

WELL	FEED DEPTH MEASURED ALONG WELLBORE (feet)	ELEVATION ABOVE SEA LEVEL (feet)	PRESSURE (psig)
4	4500	4843	1070
5A	6250	3061	1685
6	3700	5058	950
10	4500	4252	1260
13	4500	4836	1070
14	4500	4251	1215
16	5500	4189	1290
17	2750	6612	485
18	3250	5543	800
19	4000	5177	955

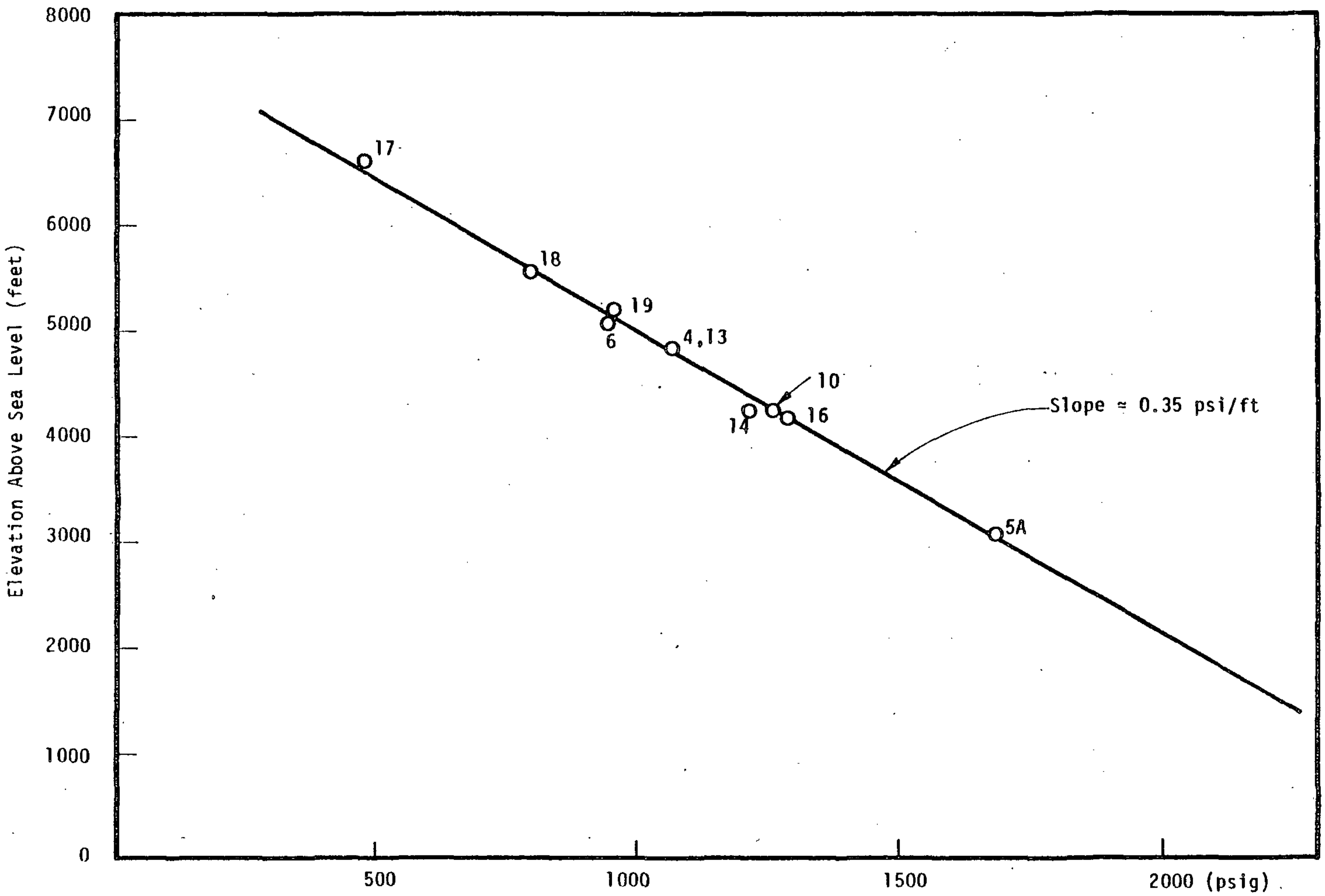

Figure 4.4. Baca Reservoir Pressures

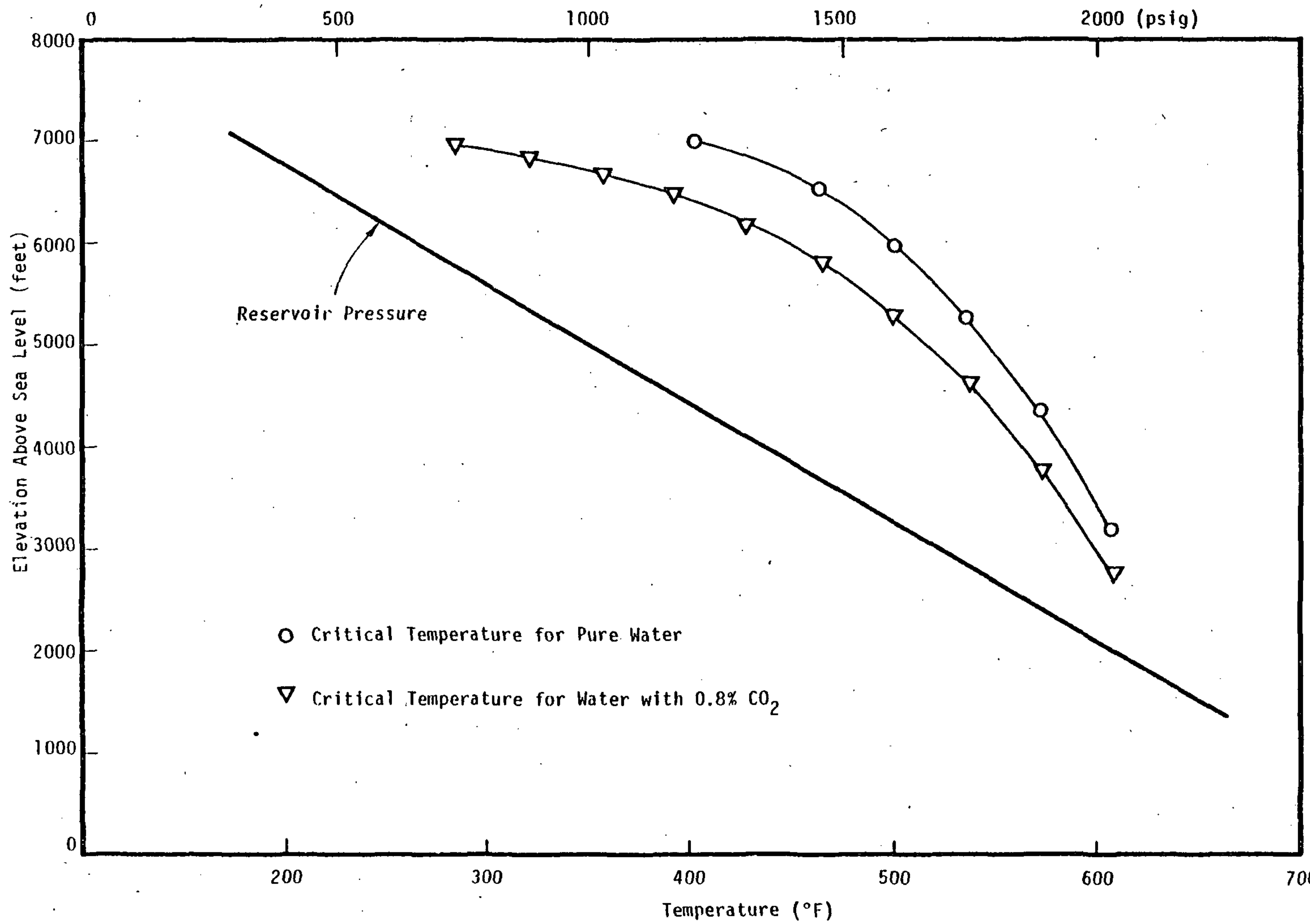

Figure 4.5. Baca Reservoir Pressure; and Critical Temperature for Two-Phase Behavior as a Function of Elevation Above Sea Level (feet) for Pure Water and for 0.8% CO_2 Mass Fraction in the Fluid.

average value for incondensable gas content (principally CO_2) in the discharge fluid is about 0.008. In this connection, it should be noted that the reported CO_2 contents are those of the fluid discharging from wells in transient flow tests, which could differ substantially from the CO_2 mass fraction in the reservoir itself (Pritchett, et al. [1981]). Atkinson [1980b] observes that the CO_2 content of the Baca system is much lower, based upon temperature and pressure measurements made within flowing wells. He notes that the locii of pressure/temperature points in such measurements are in close agreement with the saturation curve for pure water. In their discussion of the CO_2 content of Baca reservoir fluids, however, Pritchett, et al. [1981] conclude that pressure/temperature measurement correlations in flowing wells are unlikely to prove useful for determination of reservoir CO_2 content unless the CO_2 content is much greater than that believed to prevail at Baca (~ 0.8 percent); chemical analyses of discharge fluids should prove much more reliable indicators.

Figure 4.5 shows the critical temperature - elevation data for two-phase behavior for pure water and for 0.8 percent CO_2 mass fraction in the reservoir fluid. The presence of CO_2 substantially lowers the range of reservoir temperatures for which the onset of two-phase behavior will occur. In the next subsection, we will utilize the data of Figure 4.5 together with the inferred reservoir temperature to delineate the two-phase fluid region at Baca.

4.6 Reservoir Temperatures, Two-Phase Region and Caprock

Figures 4.6 and 4.7 show the temperature distribution in the reservoir as inferred from our analyses of downhole temperature surveys (Section 3). Temperatures influenced by convective effects in the wellbore were ignored and smooth contours drawn. It is worth

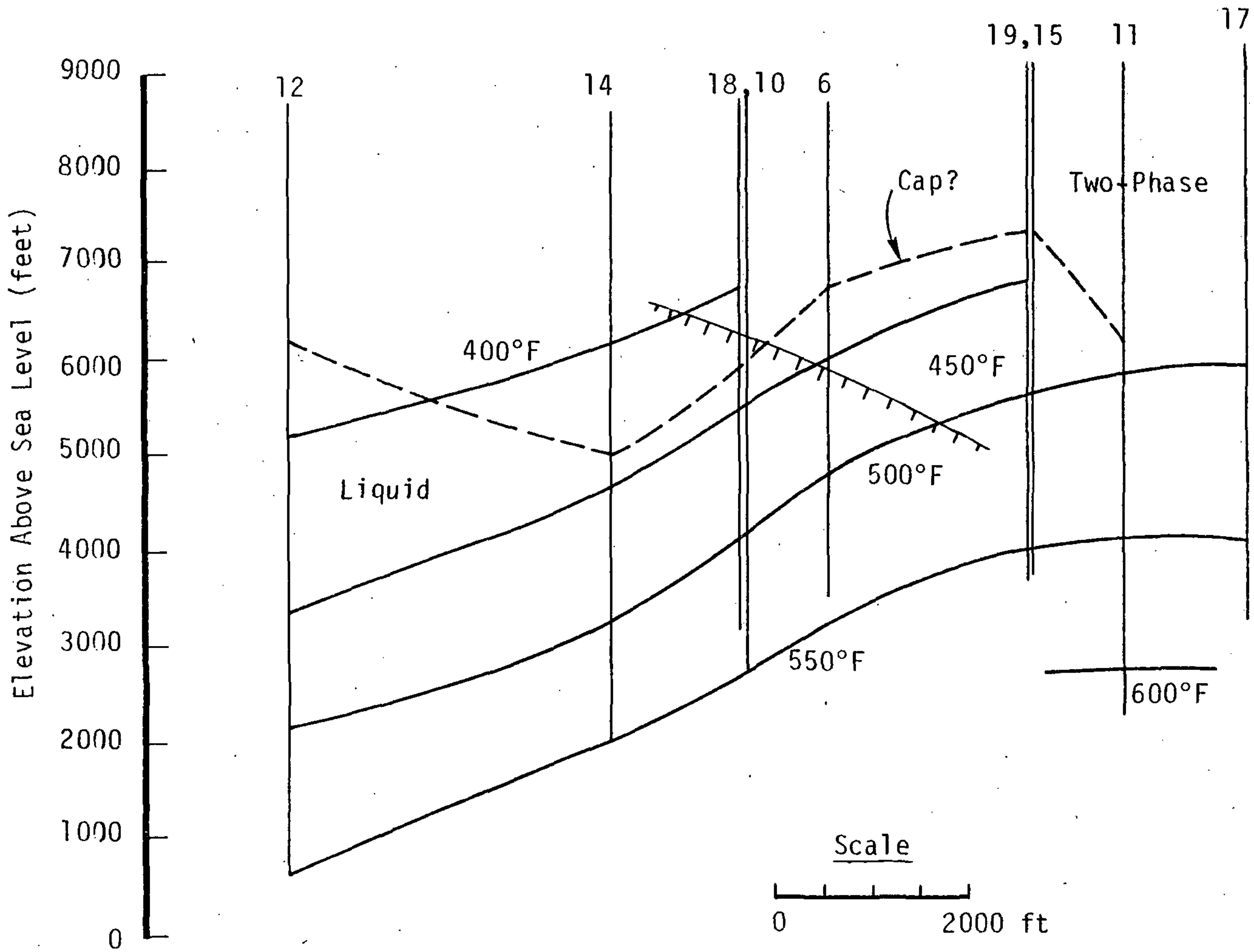

Figure 4.6. Inferred Reservoir Temperature (AA'). Shows the Boundary Between the Liquid and Two-Phase Regions.

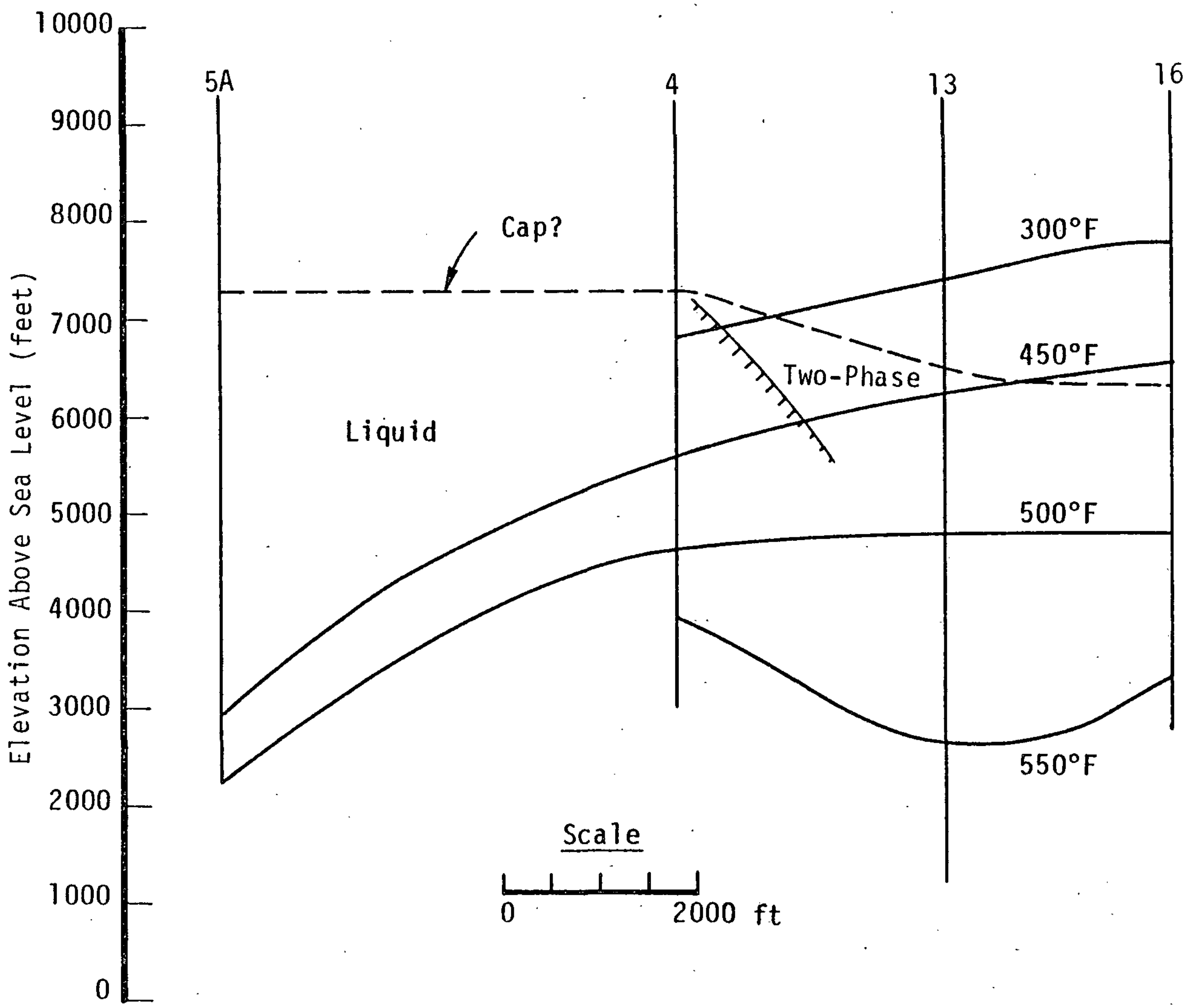

Figure 4.7. Inferred Reservoir Temperatures (BB'). Shows the Boundary Between the Liquid and Two-Phase Regions.

emphasizing here that the temperature contours, Figures 4.6 and 4.7, represent the average reservoir temperatures, and do not reflect any local temperature deviations observed in individual wells. The critical temperature - elevation data of Figure 4.5 may now be employed to delineate the two-phase zone. The striped lines in Figures 4.6 and 4.7 (assuming the reservoir fluid contains 0.8 percent CO_2 by mass) defines the boundary between the liquid and two-phase regions. It is apparent from Figures 4.6 and 4.7 that isotherms dome upwards to the north. Wells 19, 15, 11, 13 and 16 lie in the hotter part of the reservoir; the two-phase zone extends to a depth of approximately 5,000 ASL in this part of the geothermal field.

Hartz [1976] has employed downhole temperature surveys in completed Baca wells to deduce the existence of a reservoir cap (see Figures 4.6 and 4.7). Temperature profiles in the cased sections of the Baca wells are usually near linear. Extrapolating this shallow gradient to intersect the lesser gradient measured in the deeper part of the well, Hartz defines the bottom of a zone in which conduction dominates over convection. Since the conduction dominated zone must have very low permeability, this identifies the reservoir caprock.

There is a fundamental problem with the use of temperature data in cased holes to infer the existence of a caprock. It should be noted that the temperatures measured in partially drilled holes at Baca do not agree with those recorded in completed wells (see discussion of B-4 and B-16, Section 3); this casts doubt on the inference of a caprock based on the temperature measurements in the cased parts of the wells.

It may, however, be that the linear gradient in the cased section is significant for another reason. R. N. Horne (personal communication) has suggested that the linear profile represents conduction along the casing. The latter effect will dominate the temperatures in the well only if there is little permeability in the neighborhood of the well; existence of any formation permeability would permit fluid flow past the casing to affect the temperatures in the cased hole. Thus the linear profile represents a zone of reduced permeability, in so far as it implies conduction along the casing being dominant over convection in the vicinity of the wellbore. Based on this interpretation, the bottom of the caprock would be given by the end of the linear profile (i.e., not by the extrapolated intersection with the deeper gradient as implied by Hartz [1976]); this would place the reservoir top somewhat higher.

An argument for the existence of a caprock is that the region of linear gradient is roughly consistent from one well to another - provided this does not just reflect similar casing depths. Actual fluid profiles in the "caprock" above the reservoir can be defined by using shallow drilling surveys such as those from B-4 and B-16.

4.7 Baca Reservoir Model and Fluid Production

Our preliminary conceptual model of the Baca geothermal field is illustrated in Figure 4.8. The top of the reservoir is taken as the "caprock" (see also Section 4.6). Beneath that there are two zone in which permeability is found. The deeper zone closely corresponds to the contact between the Bandelier Tuff and the Andesite. The shallower zone lies within the Tuff. It appears that the shallower zone is the more permeable. The isotherms dome upward. At the crest of the dome is a region of two-phase fluid. The dotted lines indicate the shape of the contours of steam saturation within this two-phase zone. Outside the two-phase zone, contours of overpressure follow a similar trend. The isotherms and the overpressure contours suggest that, as reservoir pressures fall under exploitation, the reservoir fluid distribution will always be qualitatively similar to the present -- a "bowl" of two-phase fluid

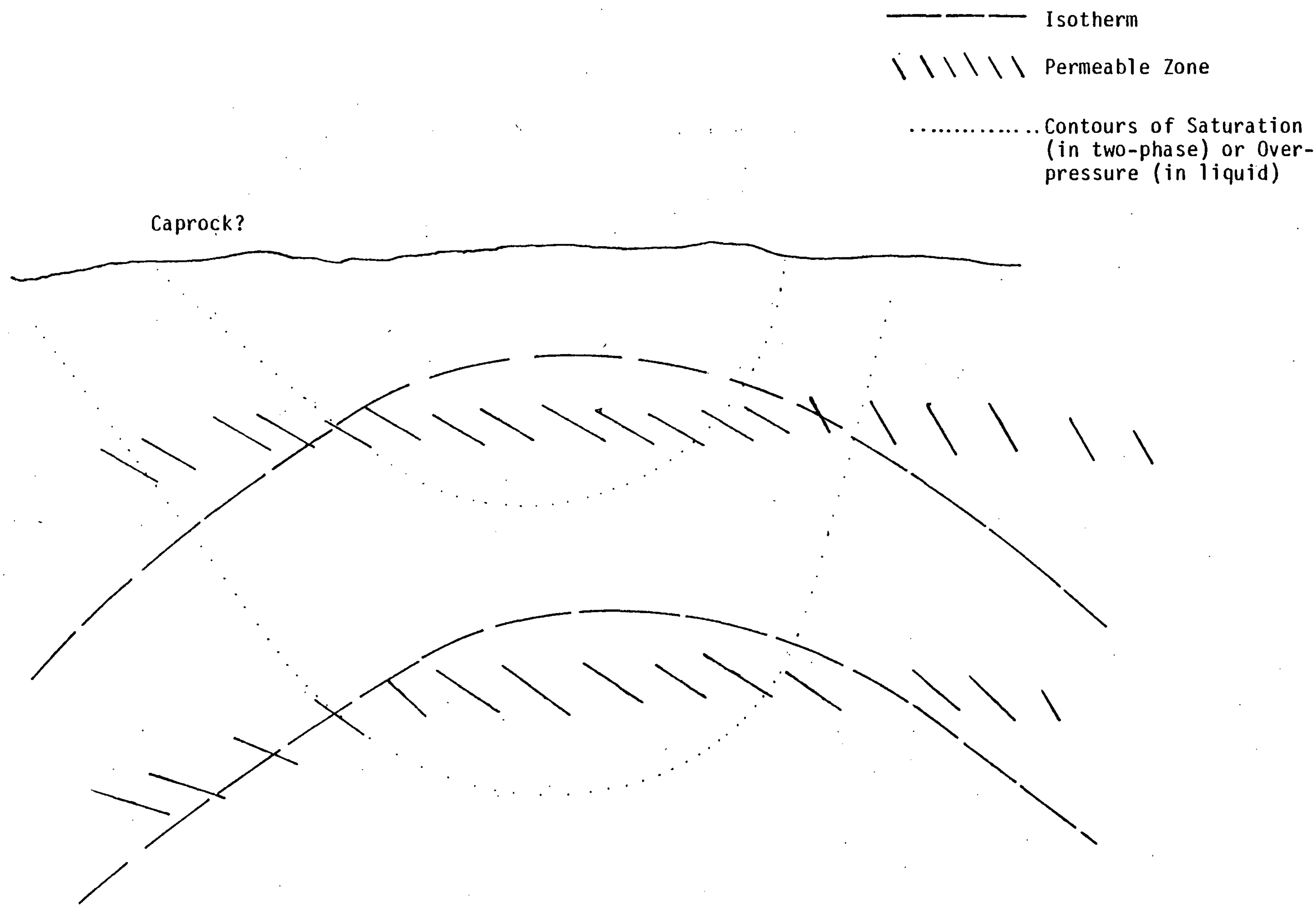

Figure 4.8. Sketch of Conceptual Baca Cross-Section.

surrounded by liquid water. With falling pressures the bowl will expand, but at all stages the reservoir will contain partly two-phase fluid and partly liquid, with a moving interface between the two.

The fluid production from Baca geothermal reservoir has previously been investigated by Hartz [1976] and by Bodvarsson, et al. [1980]. Hartz [1976] apparently followed the Whiting and Ramey [1969] approach; the reservoir is conceived as a box of compressed liquid, characterized by a single average pressure. The reservoir pressure falls rapidly with fluid removal until the boiling pressure is reached. The boiling is assumed to instantly extend to the full depth and areal extent of the reservoir. After the initiation of boiling, the subsequent pressure changes are small because of the large two-phase compressibility. Bodvarsson, et al. [1980] employed an areal model to study the production behavior of the geothermal system; the numerical results imply that the discharge from Baca wells will dry up (i.e., discharge essentially pure steam) rather rapidly.

The Whiting and Ramey model provides a gross misfit to two-phase geothermal systems (see e.g., Pritchett, et al. [1978] and Sorey and Fradkin [1979] for a discussion of this model as applied to the Wairakei, New Zealand, geothermal system). The assumption that the reservoir is initially all liquid leads to a gross overestimate of reservoir fluid volume. A geothermal system like Wairakei, part two-phase and part liquid, responds to fluid withdrawal from the liquid zone like an unconfined aquifer because the two-phase fluid region (overlying the liquid layer) has a very high compressibility. Similar considerations apply to Baca geothermal system. The only major difference at Baca, compared to Wairakei, is that at present most of the fluid production appears to come from the two-phase zone, rather than from the deeper liquid region of the reservoir.

The vertical variation in reservoir fluid (two-phase at the upper permeable zone, single-phase liquid at the lower permeable zone) indicates that a realistic simulation model must have vertical structure in it. The reservoir is sufficiently thick that compressed liquid, or two-phase fluid with mobile water, will persist at the deeper permeable zone long after the upper zone has dried out. Any estimate of the future discharge enthalpy will require vertical discrimination in the feed depths of the wells. Reservoir pressure changes in a boiling geothermal system are very sensitive to discharge enthalpy because of the great difference between the specific volumes of steam and liquid water (Garg [1980]; Grant [1978]):

$$\Delta P = Q/\phi C_T V$$

$$Q = W\left[\frac{h_t - h_w}{\rho_s} + \frac{h_s - h_t}{\rho_w}\right] ,$$

where

ΔP = pressure drop
ϕ = porosity
C_T = total compressibility
V = drainage volume
Q = fluid volume produced (evaluated at reservoir conditions)
W = fluid mass produced
h_t = discharge enthalpy
$h_w(h_s)$ = water (steam) enthalpy at reservoir conditions, and
$\rho_w(\rho_s)$ = water (steam) density at reservoir conditions.

A small rise in enthalpy markedly increases the specific volume of the two-phase mixture.

Wairakei and Broadlands geothermal systems (New Zealand) have retained their stratified fluid structure (two-phase region overlying a liquid zone) under exploitation. The Baca geothermal field, however, appears to have a much lower permeability (< 1/10) than either Wairakei or Broadlands. Thus, it is possible that production will induce such large changes in pressure, and vertical drainage of water will be so slow, that boiling conditions will rapidly extend to both the productive zones. However, this possibility must be tested by a vertical section simulation and not just assumed as done by Bodvarsson, et al. [1980].

Apparently, the upper permeable zone at Baca is more permeable. Thus at present the best production comes from a comparatively shallow region at a temperature of about 500°F. Note that the fluid in the upper zone is considerably cooler and lower in pressure than the fluid deeper down in the reservoir. Production from the wells feeding from the upper zone (e.g., B-11 and B-15) would most probably decline more rapidly than from deeper feeding wells (e.g., B-13). Figure 4.9 illustrates the consequences of reservoir exploitation by fluid removal from the upper part of the reservoir. The initial pressure profile in the reservoir is liquid-dominated, and the temperatures are at or near boiling. At abandonment, pressure in the withdrawal zone is lowered to whatever is the abandonment pressure. Beneath the withdrawal zone, pressures increase on a liquid-dominated gradient. The heat withdrawn is shown by the shaded area between the two temperature profiles in Figure 4.9. It is clear that not all the usable heat or fluid has been withdrawn from the reservoir. The fluid withdrawn is given roughly by the fall in "water level," which is about equal to the thickness of the withdrawal zone. To exploit all the usable heat and fluid requires the ability to withdraw fluid from the reservoir bottom. Thus deeper feeding wells like B-13 are of considerable importance. As far as deeper feedings wells are concerned, their ability to sustain discharge may present a possible problem area. With fluid stratification present in the reservoir, the deeper feeding wells will continue to produce a low enthalpy fluid; this

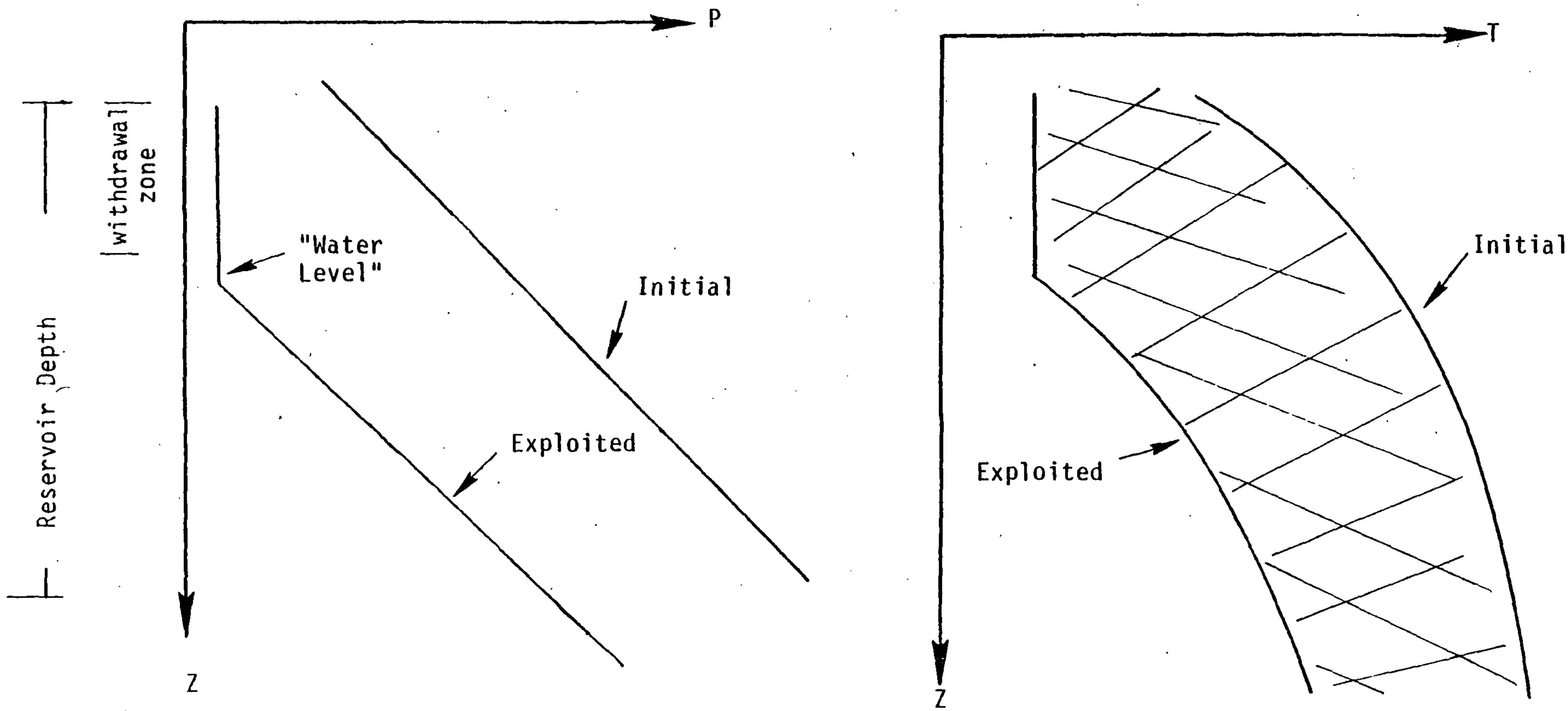

Figure 4.9. Reservoir Exploitation by Fluid Removal from Top.

fluid has greater density (and hence larger pressure drop up the flowing well) than that being produced from the upper permeable zone. There may in time be difficulty in sustaining flow at required wellhead pressure. Although there may be ample fluid in the reservoir, delivering it to wellhead becomes difficult. The latter problem has become severe at Wairakei.

It is also worth noting here a detail of the reservoir that may or may not prove to be significant. A temperature inversion often appears near the upper permeable zone; perhaps the most important instance of this is the presence of liquid water at the top feed zone of B-19. The temperature inversion implies some cross flow of liquid through the two-phase zone. This cross flow of liquid would be important if it indicated the possibility of continued or increased entry of cooler liquid into the upper withdrawal zone on fluid production. A large temperature inversion (the "cold river") crosses Broadlands field without having had any visible effect on the reservoir behavior under exploitation.

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UNION GEOTHERMAL CO. OF   BACA 20-REDRILL-1   SUMMARY

DEPTH	DIP	DIP AZM	DEV	DEV AZM	DIAM 1-3	DIAM 2-4	QUAL
TOP							
2520.0	56.8	233.	17.6	109.	8.8	8.9	
BOTTOM							
5838.0	73.8	217.	30.6	16.	9.0	8.6	

Schlumberger

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
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5802.0			30.1	15	8.6	8.6	
5804.0			30.1	14	8.7	8.6	
5806.0			30.1	16	8.7	8.6	
5808.0			30.1	18	8.7	8.6	
5810.0			30.2	18	8.7	8.7	
5812.0			30.2	18	8.8	8.6	
5814.0			30.2	19	8.8	8.6	
5816.0			30.3	18	8.8	8.6	
5818.0			30.4	17	8.8	8.6	
5820.0			30.4	17	8.8	8.6	
5822.0			30.4	17	8.8	8.7	
5824.0			30.4	17	8.8	8.6	
5826.0			30.5	17	8.8	8.6	
5828.0			30.5	17	8.8	8.6	
5830.0			30.5	17	8.9	8.6	
5832.0			30.6	16	8.9	8.6	
5834.0			30.6	16	8.9	8.7	
5838.0			30.6	16	9.0	8.6	

Schlumberger

UNION GEOTHERMAL CO. OF BACA 20-REDRILL-1 PAGE 41-FILE 1

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	DIAM 1-3	DIAM 2-4	QUAL. INDEX BEST =A
5720.0	23.5	220	28.4	17	8.4	8.6	D
5722.0			28.5	17	8.5	8.6	
5724.0			28.5	16	8.5	8.6	
5726.0			28.5	16	8.6	8.6	
5728.0			28.6	16	8.6	8.6	
5730.0			28.6	16	8.6	8.6	
5732.0			28.7	16	8.7	8.6	
5734.0			28.7	17	8.7	8.6	
5736.0			28.7	19	8.7	8.6	
5738.0			28.8	20	8.7	8.7	
5740.0			28.8	19	8.7	8.7	
5742.0	52.1	141	28.8	19	8.7	8.6	D
5744.0			28.8	19	8.6	8.7	
5746.0			28.9	19	8.6	8.7	
5748.0	59.7	133	28.9	19	8.6	8.7	D
5750.0	59.3	135	29.0	19	8.6	8.7	D
5752.0			29.0	19	8.6	8.7	
5754.0			29.1	18	8.6	8.7	
5756.0			29.1	19	8.7	8.7	
5758.0			29.2	19	8.7	8.7	
5760.0			29.2	19	8.7	8.7	
5762.0			29.3	19	8.7	8.7	
5764.0			29.3	19	8.7	8.6	
5766.0			29.4	19	8.6	8.6	
5768.0			29.4	19	8.6	8.6	
5770.0			29.4	19	8.6	8.6	
5772.0			29.4	18	8.6	8.6	
5774.0	41.7	226	29.5	17	8.5	8.6	D
5776.0	40.1	223	29.5	16	8.5	8.6	D
5778.0			29.6	14	8.5	8.6	
5780.0			29.6	14	8.5	8.6	
5782.0			29.6	15	8.5	8.6	
5784.0	52.3	177	29.6	15	8.5	8.6	D
5786.0	50.4	178	29.7	15	8.5	8.6	F
5788.0	53.3	171	29.7	15	8.5	8.6	D
5790.0	53.3	172	29.8	14	8.5	8.6	B
5792.0	53.2	173	29.8	14	8.5	8.6	B
5794.0			29.9	13	8.5	8.6	
5796.0			29.9	14	8.5	8.6	
5798.0			30.0	14	8.5	8.6	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
5640.0			27.0	19	8.6	8.7	
5642.0			27.0	19	8.6	8.7	
5644.0			27.1	20	8.6	8.6	
5646.0			27.1	20	8.6	8.6	
5648.0			27.1	20	8.6	8.6	
5650.0	34.8	164	27.2	19	8.6	8.6	B
5652.0			27.2	18	8.6	8.6	
5654.0			27.2	18	8.6	8.6	
5656.0			27.2	18	8.6	8.6	
5658.0			27.2	18	8.6	8.6	
5660.0	77.7	223	27.3	18	8.7	8.6	B
5662.0			27.3	18	8.7	8.7	
5664.0			27.4	18	8.7	8.7	
5666.0			27.4	18	8.7	8.7	
5668.0			27.5	18	8.6	8.6	
5670.0			27.5	18	8.7	8.6	
5672.0			27.6	18	8.7	8.6	
5674.0			27.6	17	8.7	8.6	
5676.0			27.7	17	8.7	8.7	
5678.0	74.5	240	27.7	18	8.7	8.7	D
5680.0			27.7	18	8.7	8.7	
5682.0			27.8	17	8.7	8.7	
5684.0			27.8	17	8.8	8.7	
5686.0			27.8	17	8.8	8.7	
5688.0			27.9	18	8.8	8.7	
5690.0			27.9	18	8.8	8.6	
5692.0	81.2	238	27.9	18	8.8	8.6	D
5694.0	84.6	238	28.0	18	8.8	8.6	D
5696.0			28.0	17	8.7	8.6	
5698.0			28.1	17	8.7	8.6	
5700.0			28.1	17	8.6	8.6	
5702.0			28.2	17	8.6	8.6	
5704.0			28.2	17	8.6	8.6	
5706.0			28.2	17	8.5	8.6	
5708.0	48.1	222	28.3	17	8.5	8.6	D
5710.0	48.3	223	28.3	17	8.5	8.6	D
5712.0	51.8	222	28.3	17	8.5	8.6	D
5714.0	54.5	221	28.4	17	8.5	8.6	D
5716.0			28.4	17	8.4	8.6	
5718.0	22.6	223	28.4	17	8.4	8.6	B

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
5560.0			26.3	20	8.9	8.7	
5562.0			26.3	20	8.9	8.7	
5564.0			26.3	20	8.9	8.7	
5566.0	83.9	290	26.3	20	8.9	8.7	B
5568.0	84.4	291	26.3	20	9.0	8.8	D
5570.0			26.3	19	9.0	8.8	
5572.0			26.3	18	9.0	8.9	
5574.0			26.3	19	9.0	8.9	
5576.0	80.6	293	26.4	19	9.0	8.7	D
5578.0			26.4	19	8.9	8.8	
5580.0			26.4	19	8.9	8.8	
5582.0	51.9	128	26.4	19	8.9	8.8	D
5584.0	49.0	130	26.4	20	8.7	8.7	D
5586.0			26.4	19	8.7	8.7	
5588.0			26.4	19	8.6	8.7	
5590.0			26.4	19	8.6	8.7	
5592.0			26.5	19	8.6	8.6	
5594.0			26.5	19	8.6	8.6	
5596.0			26.5	18	8.6	8.6	
5598.0	22.2	166	26.5	18	8.7	8.7	D
5600.0	21.4	160	26.5	18	8.7	8.7	D
5602.0	28.5	163	26.5	19	8.8	8.7	D
5604.0	60.8	144	26.5	19	8.9	8.8	D
5606.0	26.1	167	26.5	19	8.9	8.8	D
5608.0			26.5	19	8.9	8.8	
5610.0			26.5	19	8.8	8.7	
5612.0			26.6	19	8.8	8.7	
5614.0	27.5	167	26.6	19	8.8	8.7	B
5616.0	28.4	173	26.6	19	8.8	8.7	B
5618.0			26.6	18	8.8	8.6	
5620.0			26.7	18	8.8	8.6	
5622.0			26.7	18	8.7	8.7	
5624.0			26.7	19	8.6	8.7	
5626.0			26.7	19	8.6	8.7	
5628.0			26.7	19	8.6	8.7	
5630.0			26.8	19	8.6	8.7	
5632.0			26.8	19	8.6	8.7	
5634.0			26.8	19	8.6	8.7	
5636.0			26.9	19	8.7	8.7	
5638.0			26.9	19	8.6	8.7	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
5480.0			25.8	20	8.6	8.7	
5482.0			25.9	20	8.8	8.7	
5484.0			25.9	20	8.8	8.8	
5486.0			26.0	20	8.8	8.8	
5488.0			26.1	20	8.9	8.8	
5490.0			26.1	21	9.0	8.8	
5492.0			26.1	21	9.1	8.8	
5494.0			26.2	20	9.3	8.7	
5496.0			26.2	20	9.5	9.0	
5498.0			26.1	20	9.5	9.1	
5500.0			26.1	20	9.4	8.9	
5502.0			26.1	20	9.2	8.8	
5504.0			26.1	20	9.2	8.8	
5506.0			26.1	20	9.4	8.9	
5508.0			26.2	20	9.5	9.0	
5510.0			26.2	20	9.3	8.9	
5512.0			26.2	20	9.2	8.9	
5514.0			26.2	20	9.3	9.0	
5516.0			26.2	20	9.2	9.0	
5518.0			26.3	20	8.9	8.9	
5520.0	60.8	213	26.3	20	8.8	8.8	D
5522.0			26.3	19	8.9	8.8	
5524.0			26.3	19	9.1	8.9	
5526.0			26.3	20	9.6	9.0	
5528.0			26.3	20	9.8	9.2	
5530.0			26.3	19	9.4	9.1	
5532.0			26.3	20	8.9	8.8	
5534.0	58.6	211	26.2	20	8.7	8.7	B
5536.0	58.0	212	26.2	20	8.7	8.7	B
5538.0			26.2	20	8.6	8.6	
5540.0			26.2	19	8.6	8.6	
5542.0			26.2	20	8.6	8.6	
5544.0			26.1	20	8.6	8.6	
5546.0			26.1	20	8.5	8.7	
5548.0			26.1	19	8.5	8.7	
5550.0			26.1	19	8.6	8.7	
5552.0			26.1	19	8.6	8.7	
5554.0			26.2	19	8.7	8.7	
5556.0			26.2	19	8.7	8.6	
5558.0			26.2	20	8.8	8.7	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
5400.0			25.6	22	8.7	8.7	
5402.0			25.7	22	8.7	8.8	
5404.0			25.7	23	8.8	8.8	
5406.0	20.8	355	25.7	23	8.9	8.7	D
5408.0	21.4	351	25.7	23	9.0	8.8	D
5410.0			25.6	23	9.0	8.7	
5412.0	21.3	352	25.6	23	8.9	8.7	D
5414.0			25.6	22	8.8	8.8	
5416.0			25.6	21	8.7	8.8	
5418.0			25.6	22	8.7	8.8	
5420.0			25.6	22	8.7	8.7	
5422.0			25.6	22	8.7	8.7	
5424.0			25.6	21	8.8	8.7	
5426.0			25.6	21	8.8	8.7	
5428.0			25.6	21	8.8	8.7	
5430.0			25.6	21	8.7	8.7	
5432.0			25.5	21	8.8	8.8	
5434.0			25.5	21	8.9	8.8	
5436.0			25.5	22	8.7	8.7	
5438.0			25.5	21	8.6	8.7	
5440.0	49.5	243	25.5	21	8.6	8.6	D
5442.0	50.0	243	25.6	20	8.6	8.6	B
5444.0	47.7	244	25.6	20	8.6	8.6	D
5446.0			25.6	19	8.6	8.7	
5448.0			25.6	18	8.5	8.6	
5450.0			25.6	17	8.6	8.6	
5452.0			25.6	17	8.5	8.6	
5454.0			25.6	19	8.6	8.6	
5456.0			25.6	19	8.6	8.7	
5458.0			25.6	19	8.6	8.6	
5460.0			25.5	19	8.6	8.6	
5462.0			25.5	19	8.6	8.6	
5464.0			25.5	19	8.5	8.6	
5466.0			25.5	20	8.5	8.6	
5468.0			25.6	20	8.5	8.6	
5470.0			25.6	20	8.5	8.6	
5472.0			25.6	20	8.5	8.6	
5474.0			25.7	20	8.5	8.6	
5476.0			25.7	20	8.5	8.6	
5478.0			25.8	20	8.5	8.6	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
5320.0			25.4	23	8.7	8.8	
5322.0			25.4	23	9.8	9.9	
5324.0			25.4	23	10.3	10.5	
5326.0			25.4	24	9.4	9.3	
5328.0			25.4	24	8.9	8.7	
5330.0			25.4	24	8.8	8.7	
5332.0			25.5	23	8.8	8.7	
5334.0			25.5	24	8.9	8.7	
5336.0			25.5	24	8.9	8.6	
5338.0			25.5	23	8.9	8.7	
5340.0			25.5	23	8.8	8.7	
5342.0			25.5	23	8.8	8.7	
5344.0			25.5	23	8.8	8.7	
5346.0			25.4	23	8.7	8.6	
5348.0			25.4	23	8.8	8.7	
5350.0			25.4	24	8.8	8.7	
5352.0			25.4	23	8.8	8.6	
5354.0			25.4	23	8.8	8.6	
5356.0			25.4	24	8.8	8.6	
5358.0			25.4	24	8.7	8.7	
5360.0	80.9	175	25.4	24	8.7	8.7	D
5362.0			25.4	23	8.7	8.7	
5364.0			25.5	23	8.7	8.7	
5366.0	62.2	192	25.5	22	8.6	8.7	D
5368.0	61.8	191	25.5	21	8.6	8.7	D
5370.0			25.5	20	8.6	8.7	
5372.0			25.5	20	8.6	8.7	
5374.0	78.0	172	25.5	19	8.6	8.7	D
5376.0			25.5	19	8.6	8.7	
5378.0			25.5	20	8.6	8.7	
5380.0			25.5	20	8.6	8.7	
5382.0			25.5	20	8.7	8.7	
5384.0			25.5	20	8.8	8.7	
5386.0			25.5	21	8.8	8.7	
5388.0			25.6	21	8.8	8.6	
5390.0			25.6	21	8.8	8.6	
5392.0			25.6	21	8.7	8.6	
5394.0			25.6	21	8.7	8.6	
5396.0			25.6	21	8.7	8.7	
5398.0			25.6	22	8.7	8.7	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	DIAM 1-3	DIAM 2-4	QUAL. INDEX BEST =A
5240.0			24.6	23	8.8	8.7	
5242.0			24.6	24	8.9	8.7	
5244.0			24.6	24	8.9	8.7	
5246.0			24.6	24	8.9	8.7	
5248.0			24.6	24	8.9	8.7	
5250.0			24.6	25	8.8	8.7	
5252.0			24.7	25	8.8	8.8	
5254.0			24.6	25	8.6	8.8	
5256.0			24.6	24	8.7	8.8	
5258.0	51.2	219	24.7	25	8.9	8.8	D
5260.0	52.0	212	24.7	24	9.0	8.8	D
5262.0			24.7	24	8.8	8.7	
5264.0			24.7	24	8.7	8.7	
5266.0	15.4	331	24.8	24	8.7	8.7	D
5268.0	17.8	329	24.8	23	8.7	8.7	D
5270.0	19.8	318	24.8	24	8.9	8.8	D
5272.0	23.8	330	24.9	23	8.9	8.8	D
5274.0			25.0	23	8.8	8.8	
5276.0	53.4	215	25.0	23	8.9	8.7	B
5278.0			25.0	24	8.9	8.7	
5280.0			25.0	23	9.0	8.6	
5282.0	85.6	349	25.0	23	9.2	8.7	D
5284.0	80.9	355	25.0	24	9.5	9.2	B
5286.0	78.5	126	25.1	23	9.6	9.7	B
5288.0	75.6	127	25.1	23	9.5	9.3	B
5290.0			25.1	23	9.2	8.8	
5292.0			25.2	23	9.0	8.9	
5294.0			25.2	21	8.8	8.8	
5296.0			25.2	20	8.8	8.7	
5298.0			25.2	20	8.8	8.7	
5300.0			25.2	19	8.7	8.7	
5302.0			25.2	19	8.7	8.7	
5304.0			25.2	20	8.7	8.7	
5306.0			25.2	21	8.7	8.8	
5308.0			25.2	21	8.7	8.8	
5310.0			25.2	22	8.7	8.8	
5312.0			25.3	23	8.7	8.8	
5314.0			25.3	23	8.7	8.8	
5316.0			25.3	23	8.8	8.8	
5318.0			25.4	24	8.7	8.8	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	DIAM 1-3	DIAM 2-4	QUAL. INDEX BEST =A
5160.0			24.2	25	9.3	9.2	
5162.0			24.3	25	8.7	8.8	
5164.0			24.3	25	8.6	8.8	
5166.0			24.4	25	8.6	8.7	
5168.0			24.4	24	8.6	8.6	
5170.0			24.4	24	8.7	8.7	
5172.0			24.4	24	8.7	8.7	
5174.0			24.4	25	8.7	8.7	
5176.0			24.3	25	8.7	8.7	
5178.0			24.3	25	8.7	8.7	
5180.0			24.3	25	8.6	8.7	
5182.0			24.3	25	8.6	8.7	
5184.0			24.3	25	8.6	8.7	
5186.0			24.3	25	8.6	8.7	
5188.0			24.3	25	8.6	8.7	
5190.0			24.3	25	8.7	8.7	
5192.0	27.8	200	24.3	25	8.7	8.7	B
5194.0			24.4	25	8.6	8.7	
5196.0			24.4	25	8.6	8.7	
5198.0			24.4	25	8.7	8.7	
5200.0			24.4	26	8.7	8.7	
5202.0			24.4	26	8.7	8.7	
5204.0			24.5	25	8.7	8.8	
5206.0			24.5	26	8.8	8.8	
5208.0			24.5	26	8.7	8.7	
5210.0			24.6	25	8.7	8.7	
5212.0			24.6	25	8.7	8.7	
5214.0	85.1	68	24.6	24	8.7	8.6	F
5216.0			24.6	23	8.7	8.7	
5218.0			24.6	23	8.7	8.7	
5220.0			24.6	23	8.7	8.7	
5222.0			24.6	22	8.7	8.7	
5224.0			24.6	21	8.6	8.7	
5226.0			24.7	22	8.5	8.7	
5228.0			24.7	23	8.6	8.7	
5230.0			24.7	24	8.7	8.6	
5232.0			24.7	24	8.9	8.6	
5234.0			24.7	24	9.0	8.7	
5236.0			24.6	23	9.0	8.7	
5238.0			24.6	24	8.9	8.7	

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	DIAM 1-3	DIAM 2-4	QUAL. INDEX BEST =A
5080.0	29.2	259	24.0	27	9.0	8.9	B
5082.0	18.2	235	24.0	27	8.9	8.9	F
5084.0			24.0	27	8.7	8.7	
5086.0	29.9	262	24.0	27	8.6	8.7	D
5088.0			24.0	27	8.7	8.7	
5090.0			24.1	27	8.8	8.7	
5092.0			24.1	27	8.7	8.7	
5094.0			24.1	27	8.7	8.7	
5096.0			24.1	26	8.7	8.7	
5098.0			24.2	26	8.8	8.8	
5100.0			24.1	26	8.7	8.7	
5102.0			24.1	26	8.7	8.7	
5104.0	35.6	344	24.1	26	8.8	8.8	D
5106.0	38.5	348	24.1	26	8.9	8.8	D
5108.0			24.1	26	8.8	8.8	
5110.0			24.2	26	8.7	8.8	
5112.0			24.2	26	8.7	8.8	
5114.0			24.2	26	8.7	8.8	
5116.0			24.2	25	8.7	8.8	
5118.0			24.3	26	8.7	8.8	
5120.0			24.3	26	8.7	8.8	
5122.0			24.3	26	8.7	8.8	
5124.0			24.3	26	8.7	8.8	
5126.0	11.9	209	24.3	26	8.6	8.7	D
5128.0			24.3	26	8.6	8.7	
5130.0	11.4	219	24.3	25	8.7	8.8	B
5132.0			24.4	25	8.6	8.8	
5134.0			24.4	26	8.7	8.8	
5136.0			24.4	26	8.7	8.7	
5138.0			24.5	26	8.8	8.7	
5140.0			24.5	26	8.9	8.7	
5142.0	20.7	213	24.4	25	9.7	9.6	D
5144.0	18.0	204	24.4	25	10.8	10.7	B
5146.0	13.9	118	24.3	25	10.0	9.9	F
5148.0			24.3	26	9.0	8.8	
5150.0	26.4	215	24.2	26	9.0	8.8	D
5152.0			24.2	25	9.0	8.8	
5154.0	15.8	141	24.2	26	8.9	8.8	D
5156.0			24.2	26	8.8	8.7	
5158.0			24.2	26	9.2	9.1	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
5000.0			23.5	26	8.7	8.8	
5002.0			23.6	26	8.7	8.8	
5004.0			23.6	26	8.6	8.7	
5006.0			23.6	26	8.6	8.7	
5008.0			23.7	26	8.6	8.7	
5010.0			23.7	27	8.6	8.7	
5012.0			23.8	27	8.6	8.8	
5014.0			23.8	27	8.7	8.9	
5016.0			23.8	27	8.7	8.9	
5018.0			23.8	27	8.7	8.8	
5020.0			23.8	27	8.7	8.8	
5022.0			23.9	26	8.7	8.7	
5024.0			23.9	26	8.7	8.8	
5026.0			23.9	26	8.7	8.8	
5028.0			23.9	26	8.7	8.7	
5030.0			23.9	26	8.6	8.7	
5032.0			23.9	26	8.6	8.7	
5034.0			23.9	26	8.6	8.7	
5036.0			24.0	26	8.7	8.7	
5038.0			24.0	26	8.6	8.8	
5040.0			24.0	26	8.6	8.8	
5042.0			24.1	26	8.7	8.8	
5044.0			24.1	26	8.7	8.8	
5046.0			24.1	26	8.7	8.7	
5048.0			24.2	26	8.6	8.7	
5050.0	33.8	250	24.2	26	8.6	8.7	D
5052.0	30.4	248	24.2	26	8.6	8.7	F
5054.0	33.5	256	24.2	28	8.6	8.7	D
5056.0			24.2	27	8.6	8.7	
5058.0			24.2	26	8.7	8.8	
5060.0			24.2	26	8.7	8.8	
5062.0			24.2	26	8.7	8.7	
5064.0			24.2	26	8.8	8.7	
5066.0			24.2	27	8.9	8.9	
5068.0			24.1	27	8.9	8.8	
5070.0			24.1	25	8.8	8.8	
5072.0			24.1	25	8.9	8.8	
5074.0			24.1	26	8.8	8.7	
5076.0			24.1	26	8.6	8.7	
5078.0	32.7	254	24.0	27	8.8	8.8	D

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4920.0	71.0	325	23.1	28	8.5	8.6	B
4922.0			23.1	29	8.5	8.6	
4924.0			23.1	29	8.6	8.7	
4926.0			23.1	28	8.5	8.7	
4928.0			23.1	28	8.6	8.8	
4930.0			23.1	28	8.8	8.8	
4932.0			23.1	28	8.7	8.8	
4934.0	63.4	84	23.1	29	8.6	8.7	F
4936.0			23.1	29	8.6	8.8	
4938.0			23.1	29	8.6	8.8	
4940.0			23.2	29	8.8	8.8	
4942.0			23.2	29	8.8	8.8	
4944.0			23.2	29	8.7	8.8	
4946.0			23.1	29	8.6	8.8	
4948.0			23.1	29	8.6	8.8	
4950.0			23.1	29	8.6	8.8	
4952.0			23.1	30	8.6	8.8	
4954.0			23.1	30	8.6	8.8	
4956.0			23.1	29	8.7	8.8	
4958.0			23.1	29	8.8	8.9	
4960.0			23.1	28	8.9	9.0	
4962.0			23.1	28	8.9	9.0	
4964.0			23.1	28	8.9	9.0	
4966.0			23.1	27	8.9	9.0	
4968.0			23.1	27	8.9	9.1	
4970.0			23.1	27	8.8	9.1	
4972.0			23.2	28	8.7	8.9	
4974.0			23.3	28	8.6	8.8	
4976.0			23.3	27	8.6	8.8	
4978.0			23.3	27	8.7	8.8	
4980.0			23.4	28	8.8	8.8	
4982.0			23.4	28	8.8	8.8	
4984.0			23.4	27	8.7	8.8	
4986.0			23.5	26	8.8	8.8	
4988.0			23.5	26	8.7	8.8	
4990.0			23.5	26	8.7	8.8	
4992.0			23.5	27	8.7	8.8	
4994.0			23.5	27	8.8	8.8	
4996.0			23.5	26	8.8	8.9	
4998.0			23.5	26	8.7	8.8	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4840.0			24.0	31	8.6	8.8	
4842.0			24.1	32	8.6	8.8	
4844.0	26.2	125	24.1	32	8.6	8.8	B
4846.0	20.7	143	24.1	32	8.6	8.8	D
4848.0	21.2	127	24.1	33	8.6	8.8	D
4850.0			24.1	33	8.6	8.8	
4852.0			24.1	33	8.6	8.8	
4854.0	22.6	129	24.1	33	8.6	8.7	D
4856.0	21.9	116	24.0	32	8.6	8.7	D
4858.0	51.0	246	24.0	32	8.6	8.7	F
4860.0	56.0	247	23.9	32	8.6	8.7	D
4862.0	54.4	246	23.9	31	8.6	8.7	D
4864.0			23.9	31	8.6	8.8	
4866.0			23.9	31	8.6	8.8	
4868.0	47.5	250	23.8	31	8.6	8.7	D
4870.0			23.8	31	8.7	8.8	
4872.0			23.8	31	8.6	8.8	
4874.0			23.8	31	8.6	8.8	
4876.0			23.8	31	8.6	8.8	
4878.0			23.7	30	8.6	8.7	
4880.0			23.7	30	8.6	8.7	
4882.0			23.7	30	8.6	8.7	
4884.0			23.7	30	8.6	8.7	
4886.0			23.7	30	8.6	8.7	
4888.0			23.6	30	8.6	8.7	
4890.0			23.6	30	8.5	8.7	
4892.0			23.5	30	8.5	8.7	
4894.0			23.5	29	8.5	8.7	
4896.0			23.4	29	8.6	8.7	
4898.0			23.4	29	8.6	8.7	
4900.0			23.4	29	8.6	8.7	
4902.0			23.3	29	8.6	8.7	
4904.0			23.3	29	8.6	8.7	
4906.0			23.3	29	8.6	8.7	
4908.0			23.2	29	8.6	8.7	
4910.0			23.2	29	8.6	8.7	
4912.0			23.2	29	8.5	8.7	
4914.0			23.2	29	8.5	8.6	
4916.0			23.2	28	8.5	8.6	
4918.0	68.5	325	23.2	28	8.5	8.6	D

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	DIAM 1-3	DIAM 2-4	QUAL. INDEX BEST =A
4760.0			23.8	32	8.6	8.7	
4762.0			23.9	32	8.5	8.6	
4764.0			23.9	32	8.5	8.7	
4766.0			23.9	32	8.5	8.7	
4768.0			23.9	32	8.6	8.7	
4770.0			24.0	32	8.6	8.7	
4772.0			24.0	31	8.6	8.7	
4774.0			24.0	30	8.7	8.8	
4776.0			23.9	31	8.6	8.7	
4778.0			23.9	32	8.4	8.7	
4780.0			23.9	31	8.4	8.7	
4782.0			24.0	30	8.6	8.8	
4784.0			24.0	28	8.7	8.9	
4786.0			24.0	30	8.7	8.8	
4788.0			24.0	32	8.5	8.7	
4790.0			24.1	32	8.5	8.7	
4792.0	48.9	6	24.1	32	8.6	8.9	D
4794.0			24.1	32	8.7	8.8	
4796.0	52.7	359	24.1	32	8.5	8.7	F
4798.0			24.1	32	8.5	8.7	
4800.0			24.1	32	8.6	8.8	
4802.0			24.1	32	8.7	8.8	
4804.0	40.8	324	24.1	32	8.6	8.8	D
4806.0	41.6	322	24.2	32	8.6	8.8	F
4808.0			24.2	33	8.6	8.7	
4810.0			24.2	33	8.5	8.7	
4812.0			24.3	33	8.6	8.7	
4814.0			24.3	33	8.6	8.7	
4816.0			24.3	32	8.5	8.7	
4818.0			24.3	31	8.5	8.7	
4820.0			24.2	33	8.4	8.7	
4822.0			24.2	34	8.5	8.7	
4824.0			24.2	32	8.5	8.7	
4826.0			24.1	27	8.5	8.7	
4828.0			24.1	24	8.5	8.6	
4830.0			24.1	26	8.5	8.7	
4832.0			24.1	29	8.5	8.7	
4834.0			24.0	27	8.5	8.7	
4836.0			24.0	28	8.6	8.7	
4838.0			24.0	30	8.6	8.7	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4680.0			23.6	35	8.5	8.7	
4682.0			23.6	35	8.5	8.7	
4684.0			23.6	35	8.6	8.7	
4686.0			23.6	35	8.6	8.7	
4688.0			23.7	36	8.6	8.7	
4690.0			23.7	36	8.7	8.7	
4692.0			23.7	36	8.7	8.7	
4694.0	8.5	43	23.7	35	8.7	8.7	D
4696.0	7.4	34	23.7	35	8.8	8.7	D
4698.0			23.7	34	8.8	8.6	
4700.0			23.7	34	8.8	8.6	
4702.0			23.6	34	8.7	8.6	
4704.0			23.6	34	8.6	8.7	
4706.0			23.6	34	8.6	8.7	
4708.0			23.6	34	8.6	8.7	
4710.0			23.6	35	8.5	8.7	
4712.0			23.6	35	8.5	8.7	
4714.0			23.6	34	8.5	8.7	
4716.0			23.6	35	8.6	8.7	
4718.0			23.6	35	8.6	8.7	
4720.0			23.6	35	8.7	8.8	
4722.0			23.6	35	8.6	8.8	
4724.0			23.6	35	8.6	8.8	
4726.0			23.7	34	8.6	8.7	
4728.0			23.7	35	8.6	8.7	
4730.0			23.7	34	8.7	8.7	
4732.0			23.7	34	8.7	8.7	
4734.0			23.8	35	8.7	8.8	
4736.0			23.8	35	8.6	8.7	
4738.0			23.9	34	8.6	8.7	
4740.0			23.9	34	8.7	8.7	
4742.0			23.8	33	8.7	8.7	
4744.0			23.8	33	8.8	8.8	
4746.0			23.8	33	8.8	8.9	
4748.0			23.7	33	8.7	8.8	
4750.0			23.7	33	8.7	8.7	
4752.0			23.7	33	8.6	8.7	
4754.0			23.7	33	8.6	8.7	
4756.0			23.7	33	8.5	8.7	
4758.0			23.8	32	8.5	8.7	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4600.0	65.9	105	23.1	36	9.0	9.0	B
4602.0			23.1	37	8.9	9.0	
4604.0			23.1	37	8.8	9.0	
4606.0			23.1	36	8.8	8.9	
4608.0			23.1	35	8.8	8.8	
4610.0			23.1	35	8.7	8.7	
4612.0			23.2	35	8.7	8.8	
4614.0			23.2	35	8.7	8.7	
4616.0			23.2	34	8.7	8.7	
4618.0			23.2	34	8.7	8.7	
4620.0	59.6	356	23.2	34	8.5	8.7	B
4622.0			23.2	34	8.5	8.7	
4624.0			23.2	34	8.5	8.7	
4626.0			23.2	35	8.6	8.7	
4628.0			23.3	35	8.6	8.7	
4630.0			23.3	34	8.7	8.7	
4632.0			23.4	34	8.8	8.7	
4634.0			23.4	34	8.8	8.7	
4636.0			23.4	34	8.8	8.6	
4638.0			23.4	34	8.7	8.7	
4640.0			23.4	34	8.7	8.7	
4642.0			23.4	34	8.7	8.6	
4644.0			23.4	35	8.7	8.6	
4646.0			23.4	35	8.7	8.6	
4648.0			23.5	35	8.7	8.7	
4650.0			23.5	36	8.6	8.7	
4652.0			23.5	36	8.6	8.8	
4654.0			23.4	36	8.6	8.8	
4656.0			23.5	36	8.6	8.8	
4658.0			23.5	35	8.6	8.7	
4660.0			23.5	34	8.7	8.7	
4662.0			23.5	34	8.7	8.6	
4664.0			23.5	34	8.7	8.6	
4666.0			23.6	35	8.7	8.7	
4668.0			23.6	35	8.7	8.7	
4670.0			23.6	35	8.7	8.7	
4672.0			23.6	35	8.7	8.6	
4674.0			23.6	35	8.6	8.6	
4676.0			23.6	35	8.6	8.7	
4678.0			23.6	36	8.6	8.7	

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4520.0			22.7	31	8.7	8.7	
4522.0			22.7	32	8.7	8.7	
4524.0			22.7	33	8.6	8.7	
4526.0			22.7	34	8.7	8.7	
4528.0			22.7	34	8.6	8.7	
4530.0			22.7	34	8.7	8.7	
4532.0			22.8	35	8.7	8.7	
4534.0			22.8	35	8.7	8.7	
4536.0			22.7	35	8.6	8.7	
4538.0			22.7	36	8.6	8.6	
4540.0			22.7	36	8.6	8.7	
4542.0			22.7	36	8.6	8.7	
4544.0			22.7	36	8.6	8.7	
4546.0			22.7	36	8.6	8.7	
4548.0			22.8	36	8.8	8.8	
4550.0			22.8	35	8.9	8.8	
4552.0			22.8	35	8.8	8.8	
4554.0			22.7	36	8.6	8.7	
4556.0			22.8	36	8.6	8.7	
4558.0			22.8	36	8.6	8.6	
4560.0			22.8	36	8.6	8.6	
4562.0			22.8	36	8.6	8.6	
4564.0			22.8	36	8.6	8.6	
4566.0			22.9	36	8.6	8.7	
4568.0			22.9	37	8.6	8.7	
4570.0			22.9	37	8.5	8.7	
4572.0			22.9	36	8.5	8.7	
4574.0			22.9	36	8.5	8.7	
4576.0			22.9	36	8.5	8.6	
4578.0			22.9	36	8.6	8.7	
4580.0			22.9	36	8.6	8.7	
4582.0			23.0	36	8.7	8.8	
4584.0			23.0	36	8.6	8.7	
4586.0	44.4	277	23.0	36	8.6	8.7	D
4588.0	48.2	286	23.0	36	8.7	8.8	D
4590.0	52.3	291	23.0	36	8.7	8.8	D
4592.0			23.0	36	8.7	8.8	
4594.0	48.5	280	23.0	36	8.6	8.7	D
4596.0			23.1	36	8.6	8.7	
4598.0			23.1	36	8.8	8.8	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4440.0			22.7	31	8.6	8.7	
4442.0	49.4	213	22.7	33	8.6	8.8	D
4444.0	49.2	215	22.7	36	8.6	8.7	D
4446.0			22.7	40	8.6	8.7	
4448.0			22.7	42	8.6	8.7	
4450.0			22.6	43	8.7	8.7	
4452.0			22.6	44	8.8	8.8	
4454.0			22.6	44	8.7	9.0	
4456.0			22.6	44	8.6	9.0	
4458.0			22.6	44	8.6	8.7	
4460.0			22.6	44	8.5	8.7	
4462.0			22.7	45	8.6	8.8	
4464.0			22.7	46	8.6	8.8	
4466.0			22.8	46	8.6	8.8	
4468.0	83.5	90	22.8	47	8.6	8.7	B
4470.0	83.6	89	22.9	47	8.6	8.7	B
4472.0	17.0	323	22.9	48	8.6	8.7	B
4474.0	16.4	333	22.9	49	8.6	8.7	D
4476.0			22.8	50	8.5	8.7	
4478.0			22.8	50	8.5	8.6	
4480.0	42.2	276	22.8	50	8.5	8.7	D
4482.0	40.7	275	22.8	49	8.5	8.7	D
4484.0	46.5	279	22.8	48	8.5	8.7	D
4486.0	44.1	276	22.8	48	8.5	8.6	D
4488.0			22.8	46	8.5	8.7	
4490.0			22.8	43	8.6	8.7	
4492.0	42.7	281	22.8	40	8.7	8.8	D
4494.0	62.3	147	22.8	37	8.9	8.9	D
4496.0	64.3	144	22.8	35	9.1	8.9	D
4498.0			22.8	32	8.8	8.8	
4500.0			22.8	29	8.6	8.7	
4502.0			22.8	26	8.6	8.7	
4504.0			22.8	23	8.5	8.7	
4506.0			22.8	22	8.5	8.7	
4508.0			22.8	24	8.6	8.7	
4510.0			22.8	25	8.6	8.7	
4512.0			22.8	26	8.6	8.7	
4514.0			22.8	27	8.6	8.7	
4516.0			22.8	29	8.6	8.7	
4518.0			22.7	31	8.6	8.7	

Schlumberger

	FORMATION		BOREHOLE				QUAL. INDEX
DEPTH	DIP	DIP AZI.	DEV.	DEV. AZI.	DIAM 1-3	DIAM 2-4	BEST =A
4360.0	39.9	232	22.6	32	8.4	8.6	D
4362.0			22.7	32	8.4	8.6	
4364.0	45.8	237	22.6	32	8.4	8.6	D
4366.0	38.7	233	22.6	31	8.4	8.6	B
4368.0	37.0	235	22.6	31	8.4	8.6	D
4370.0			22.6	31	8.4	8.6	
4372.0	41.1	235	22.6	31	8.4	8.6	D
4374.0			22.6	31	8.4	8.6	
4376.0			22.6	31	8.4	8.7	
4378.0	45.2	235	22.6	31	8.4	8.7	A
4380.0	51.9	237	22.6	31	8.4	8.7	E
4382.0	47.0	234	22.6	30	8.4	8.7	A
4384.0	41.0	232	22.6	30	8.4	8.6	A
4386.0	39.1	234	22.6	30	8.4	8.7	C
4388.0	43.4	240	22.6	31	8.5	8.7	A
4390.0	40.4	229	22.6	31	8.5	8.7	C
4392.0	38.3	240	22.7	31	8.5	8.7	A
4394.0	39.7	241	22.6	31	8.4	8.7	A
4396.0	44.9	234	22.6	30	8.4	8.7	A
4398.0	48.4	232	22.6	30	8.4	8.7	D
4400.0	48.1	241	22.6	30	8.4	8.7	D
4402.0	46.8	236	22.6	30	8.4	8.7	B
4404.0	55.1	215	22.6	30	8.4	8.7	D
4406.0	39.7	214	22.6	29	8.4	8.7	D
4408.0	40.1	217	22.6	29	8.4	8.7	F
4410.0	54.8	215	22.6	29	8.4	8.7	B
4412.0			22.7	29	8.5	8.7	
4414.0	58.3	220	22.7	29	8.5	8.7	D
4416.0	44.4	228	22.7	29	8.5	8.7	D
4418.0			22.7	29	8.5	8.7	
4420.0			22.7	29	8.5	8.7	
4422.0			22.7	29	8.5	8.7	
4424.0			22.8	29	8.6	8.8	
4426.0			22.8	29	8.6	8.8	
4428.0			22.8	30	8.7	8.7	
4430.0			22.8	31	8.7	8.8	
4432.0	57.6	62	22.8	32	8.6	8.8	B
4434.0			22.7	33	8.5	8.8	
4436.0			22.7	33	8.5	8.7	
4438.0			22.7	31	8.6	8.7	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4280.0			22.7	36	8.4	8.6	
4282.0	38.3	190	22.7	36	8.4	8.6	B
4284.0	37.7	189	22.7	36	8.4	8.6	B
4286.0	52.7	228	22.8	35	8.4	8.6	D
4288.0	52.3	227	22.8	35	8.4	8.6	D
4290.0	43.9	198	22.8	36	8.4	8.6	D
4292.0			22.8	36	8.4	8.5	
4294.0			22.8	36	8.5	8.7	
4296.0			22.8	36	8.5	8.7	
4298.0			22.9	35	8.5	8.6	
4300.0			22.9	34	8.5	8.6	
4302.0			22.9	35	8.4	8.6	
4304.0			22.9	35	8.4	8.6	
4306.0			22.9	35	8.4	8.6	
4308.0			22.9	34	8.4	8.6	
4310.0			22.9	34	8.4	8.6	
4312.0			22.9	34	8.4	8.6	
4314.0			22.8	34	8.4	8.6	
4316.0			22.8	34	8.4	8.6	
4318.0			22.8	34	8.4	8.6	
4320.0	58.4	244	22.8	34	8.4	8.6	D
4322.0			22.8	33	8.4	8.6	
4324.0			22.8	33	8.4	8.6	
4326.0			22.8	33	8.4	8.6	
4328.0			22.8	33	8.4	8.6	
4330.0			22.8	33	8.4	8.6	
4332.0			22.8	33	8.4	8.6	
4334.0	54.0	241	22.8	33	8.4	8.6	F
4336.0	53.8	237	22.9	33	8.4	8.6	D
4338.0			22.7	33	8.4	8.6	
4340.0			22.7	33	8.4	8.6	
4342.0	46.0	228	22.7	33	8.4	8.6	D
4344.0			22.7	33	8.4	8.6	
4346.0	45.0	229	22.7	32	8.4	8.6	D
4348.0	39.7	225	22.7	33	8.4	8.6	B
4350.0			22.7	33	8.4	8.6	
4352.0	40.2	221	22.7	32	8.4	8.6	B
4354.0	40.8	217	22.7	32	8.4	8.6	D
4356.0	53.4	214	22.7	31	8.4	8.6	F
4358.0			22.6	32	8.4	8.6	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4200.0			22.8	38	8.5	8.6	
4202.0			22.8	38	8.5	8.6	
4204.0			22.8	38	8.5	8.6	
4206.0			22.8	38	8.5	8.6	
4208.0	81.5	63	22.8	37	8.5	8.5	F
4210.0			22.8	37	8.5	8.5	
4212.0	41.9	239	22.8	37	8.5	8.6	D
4214.0	43.0	240	22.8	38	8.5	8.6	D
4216.0			22.8	38	8.5	8.6	
4218.0	60.7	229	22.8	38	8.5	8.6	D
4220.0			22.8	37	8.5	8.6	
4222.0			22.8	37	8.5	8.6	
4224.0	25.7	206	22.8	37	8.6	8.6	B
4226.0	26.0	202	22.8	37	8.5	8.6	D
4228.0	62.8	229	22.8	37	8.5	8.6	B
4230.0			22.8	37	8.5	8.6	
4232.0	42.9	239	22.9	37	8.5	8.6	D
4234.0	39.3	238	22.9	37	8.5	8.6	D
4236.0			22.9	37	8.5	8.6	
4238.0	45.3	236	22.9	37	8.4	8.6	A
4240.0	48.6	243	22.9	37	8.4	8.6	A
4242.0	49.1	245	22.9	37	8.4	8.6	A
4244.0			22.8	37	8.4	8.6	
4246.0	49.9	234	22.8	37	8.4	8.6	A
4248.0	50.6	242	22.8	37	8.4	8.6	C
4250.0	49.6	249	22.8	37	8.4	8.6	A
4252.0			22.8	37	8.4	8.6	
4254.0			22.8	37	8.4	8.6	
4256.0	41.9	240	22.8	37	8.4	8.6	C
4258.0	51.5	234	22.8	36	8.4	8.6	A
4260.0	48.1	227	22.8	36	8.4	8.6	C
4262.0	43.8	223	22.8	37	8.4	8.6	C
4264.0	38.4	234	22.8	36	8.4	8.6	E
4266.0	50.1	227	22.8	36	8.4	8.6	A
4268.0	50.7	234	22.8	36	8.4	8.6	C
4270.0	45.4	233	22.8	36	8.4	8.6	E
4272.0	42.0	239	22.8	36	8.4	8.6	C
4274.0	50.8	233	22.8	36	8.4	8.6	C
4276.0	49.2	230	22.7	36	8.4	8.6	C
4278.0			22.7	36	8.4	8.6	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4120.0	50.4	242	22.7	41	8.5	8.6	D
4122.0	51.8	242	22.7	41	8.5	8.6	D
4124.0	48.3	241	22.7	41	8.4	8.6	B
4126.0			22.7	41	8.4	8.6	
4128.0	44.8	246	22.7	40	8.4	8.6	D
4130.0	50.9	234	22.8	40	8.4	8.6	D
4132.0	51.9	241	22.8	40	8.4	8.6	D
4134.0	51.9	223	22.8	40	8.4	8.6	A
4136.0	50.6	224	22.8	40	8.4	8.6	C
4138.0	45.9	227	22.8	40	8.4	8.6	A
4140.0	50.4	230	22.8	40	8.4	8.6	A
4142.0	53.1	221	22.8	40	8.4	8.6	A
4144.0	52.5	226	22.8	40	8.4	8.6	A
4146.0	57.8	219	22.8	40	8.4	8.6	A
4148.0	50.7	231	22.9	40	8.4	8.6	A
4150.0	54.0	219	22.8	40	8.4	8.6	A
4152.0	50.6	225	22.8	40	8.4	8.6	C
4154.0	50.2	235	22.8	40	8.4	8.6	A
4156.0	51.0	235	22.8	40	8.4	8.6	A
4158.0	50.3	232	22.8	40	8.4	8.6	C
4160.0	49.1	237	22.8	40	8.4	8.6	A
4162.0	49.8	231	22.8	40	8.4	8.6	C
4164.0	44.4	238	22.8	40	8.4	8.6	F
4166.0	54.6	234	22.8	40	8.5	8.6	A
4168.0	52.1	234	22.8	40	8.5	8.6	A
4170.0	46.9	247	22.8	40	8.5	8.6	B
4172.0	44.7	256	22.8	40	8.5	8.6	F
4174.0	48.3	253	22.8	39	8.5	8.6	F
4176.0	35.7	241	22.8	39	8.5	8.6	F
4178.0	53.2	234	22.8	39	8.4	8.6	A
4180.0			22.8	39	8.4	8.6	
4182.0	49.1	233	22.8	38	8.4	8.6	C
4184.0	40.4	222	22.8	38	8.4	8.7	C
4186.0	36.2	231	22.8	38	8.5	8.7	D
4188.0	58.1	217	22.8	39	8.5	8.6	C
4190.0	34.0	243	22.8	39	8.5	8.6	F
4192.0	44.9	231	22.8	39	8.5	8.6	C
4194.0	51.4	232	22.9	39	8.5	8.6	E
4196.0	53.6	226	22.8	38	8.5	8.6	A
4198.0			22.8	38	8.5	8.6	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
4040.0	45.9	249	22.2	41	8.5	8.6	F
4042.0			22.2	41	8.6	8.6	
4044.0	46.0	248	22.2	42	8.6	8.6	D
4046.0	53.0	246	22.2	41	8.5	8.6	D
4048.0	41.9	238	22.3	41	8.5	8.6	D
4050.0	55.4	245	22.3	41	8.5	8.6	D
4052.0	54.3	248	22.3	41	8.5	8.6	B
4054.0			22.3	41	8.5	8.6	
4056.0	46.2	231	22.3	41	8.5	8.6	D
4058.0			22.4	41	8.5	8.6	
4060.0	43.2	229	22.4	41	8.5	8.6	D
4062.0	45.8	233	22.4	41	8.5	8.6	D
4064.0	46.1	233	22.4	41	8.5	8.6	D
4066.0	45.2	234	22.4	41	8.5	8.6	D
4068.0	50.6	235	22.4	41	8.5	8.6	D
4070.0	43.7	236	22.5	41	8.5	8.6	D
4072.0	45.9	238	22.5	41	8.5	8.6	D
4074.0	37.4	241	22.5	42	8.5	8.6	C
4076.0	44.1	241	22.5	41	8.5	8.6	C
4078.0	41.1	250	22.5	41	8.5	8.6	E
4080.0	46.0	243	22.5	41	8.5	8.6	E
4082.0	46.3	244	22.5	42	8.5	8.6	E
4084.0	34.3	238	22.5	41	8.5	8.6	E
4086.0	39.8	235	22.5	41	8.5	8.6	E
4088.0	41.7	239	22.5	41	8.5	8.6	A
4090.0	42.1	240	22.5	41	8.5	8.6	C
4092.0	39.5	237	22.5	41	8.5	8.6	A
4094.0	42.2	234	22.6	41	8.5	8.6	A
4096.0	42.5	234	22.6	41	8.5	8.6	A
4098.0	41.0	232	22.6	41	8.5	8.6	A
4100.0	29.5	226	22.6	40	8.5	8.6	A
4102.0	42.0	224	22.7	40	8.5	8.6	A
4104.0	40.9	219	22.7	40	8.5	8.6	A
4106.0	41.5	218	22.7	40	8.5	8.6	C
4108.0			22.7	40	8.5	8.6	
4110.0			22.7	40	8.5	8.6	
4112.0			22.7	40	8.6	8.6	
4114.0			22.8	40	8.6	8.6	
4116.0	53.8	240	22.8	40	8.6	8.6	D
4118.0			22.8	40	8.5	8.6	

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	FORMATION		BOREHOLE				QUAL. INDEX
DEPTH	DIP	DIP AZI.	DEV.	DEV. AZI.	DIAM 1-3	DIAM 2-4	BEST =A
3960.0	36.9	236	21.4	42	8.5	8.6	A
3962.0	32.0	233	21.4	43	8.5	8.6	E
3964.0	38.1	230	21.5	43	8.5	8.6	A
3966.0			21.5	42	8.5	8.6	
3968.0	36.6	244	21.5	43	8.5	8.6	E
3970.0	43.7	247	21.5	43	8.5	8.6	A
3972.0	40.1	244	21.5	43	8.5	8.6	C
3974.0	39.3	249	21.6	43	8.5	8.6	D
3976.0	20.0	247	21.6	42	8.5	8.6	D
3978.0	20.2	240	21.6	42	8.5	8.6	B
3980.0	32.5	245	21.6	42	8.6	8.6	D
3982.0	10.5	68	21.6	42	8.6	8.6	B
3984.0	24.6	257	21.6	42	8.6	8.6	B
3986.0	23.1	255	21.7	42	8.5	8.6	B
3988.0	33.0	236	21.7	42	8.5	8.6	D
3990.0			21.7	43	8.5	8.6	
3992.0			21.7	42	8.5	8.6	
3994.0	50.6	242	21.7	42	8.5	8.6	D
3996.0			21.7	42	8.5	8.6	
3998.0			21.8	42	8.5	8.6	
4000.0	52.2	245	21.8	42	8.5	8.6	D
4002.0	47.7	246	21.8	42	8.5	8.6	D
4004.0	23.9	263	21.9	42	8.5	8.6	B
4006.0	23.6	268	21.9	42	8.5	8.6	D
4008.0	43.4	260	21.9	43	8.5	8.6	D
4010.0	43.3	251	21.9	43	8.5	8.6	D
4012.0	50.3	262	21.9	42	8.5	8.6	D
4014.0	38.1	253	21.9	42	8.5	8.6	A
4016.0	54.9	247	21.9	42	8.5	8.6	C
4018.0	37.7	251	21.9	42	8.5	8.6	A
4020.0	38.2	250	22.0	41	8.5	8.6	A
4022.0	51.1	257	22.0	42	8.5	8.6	C
4024.0			22.1	42	8.5	8.6	
4026.0	25.7	263	22.1	42	8.5	8.6	C
4028.0	53.5	244	22.1	42	8.5	8.6	A
4030.0	52.9	245	22.1	42	8.5	8.6	A
4032.0	52.8	246	22.1	42	8.5	8.6	C
4034.0	44.5	242	22.1	42	8.5	8.6	B
4036.0	46.7	239	22.2	41	8.5	8.6	D
4038.0	52.3	247	22.2	42	8.5	8.6	D

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3880.0			20.8	43	8.6	8.7	
3882.0			20.8	43	8.6	8.7	
3884.0			20.8	43	8.6	8.7	
3886.0			20.9	43	8.6	8.7	
3888.0			20.9	42	8.6	8.7	
3890.0			20.9	41	8.5	8.7	
3892.0			21.0	41	8.5	8.6	
3894.0			21.0	41	8.6	8.7	
3896.0			21.0	41	8.5	8.7	
3898.0			21.0	41	8.5	8.7	
3900.0			21.0	41	8.5	8.7	
3902.0			21.0	40	8.5	8.8	
3904.0			21.1	40	8.5	8.8	
3906.0			21.1	42	8.6	8.8	
3908.0	66.4	229	21.1	43	8.7	8.9	D
3910.0			21.1	43	9.2	9.3	
3912.0			21.1	42	9.4	9.5	
3914.0	52.5	261	21.1	42	9.7	9.8	D
3916.0	44.8	260	21.1	43	10.1	9.7	D
3918.0	48.2	271	21.1	42	9.5	9.2	D
3920.0			21.1	42	8.8	8.9	
3922.0			21.1	42	8.6	8.7	
3924.0	44.0	257	21.1	42	8.6	8.7	D
3926.0	45.1	257	21.2	41	8.6	8.6	D
3928.0			21.2	41	8.6	8.6	
3930.0	45.3	258	21.2	42	8.6	8.6	D
3932.0			21.2	43	8.6	8.6	
3934.0			21.2	43	8.6	8.6	
3936.0			21.2	43	8.6	8.6	
3938.0	35.5	258	21.2	43	8.6	8.6	D
3940.0			21.2	43	8.6	8.6	
3942.0	34.6	255	21.2	43	8.6	8.6	B
3944.0	34.8	259	21.3	43	8.5	8.6	D
3946.0	42.7	254	21.3	43	8.5	8.6	D
3948.0			21.3	43	8.5	8.6	
3950.0			21.3	43	8.5	8.6	
3952.0	35.3	252	21.3	43	8.5	8.6	B
3954.0	41.3	241	21.3	43	8.6	8.6	A
3956.0	32.1	239	21.3	43	8.6	8.6	C
3958.0	36.6	235	21.3	43	8.6	8.6	A

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3800.0			20.1	44	8.6	8.7	
3802.0			20.1	44	8.6	8.7	
3804.0	39.7	236	20.1	44	8.6	8.7	A
3806.0	49.2	232	20.1	44	8.6	8.7	A
3808.0			20.2	44	8.6	8.7	
3810.0	43.3	237	20.2	44	8.6	8.7	A
3812.0	43.2	237	20.2	44	8.6	8.7	A
3814.0	31.7	238	20.2	44	8.6	8.7	A
3816.0			20.3	44	8.6	8.7	
3818.0	24.5	242	20.3	44	8.6	8.7	A
3820.0	41.0	236	20.3	44	8.6	8.7	C
3822.0	42.6	248	20.3	44	8.6	8.7	A
3824.0	42.4	248	20.3	44	8.6	8.7	B
3826.0			20.3	44	8.5	8.7	
3828.0			20.3	44	8.6	8.7	
3830.0			20.4	44	8.6	8.7	
3832.0			20.4	44	8.6	8.7	
3834.0	45.6	248	20.4	44	8.5	8.7	D
3836.0			20.4	44	8.6	8.7	
3838.0			20.5	44	8.6	8.7	
3840.0			20.5	44	8.6	8.7	
3842.0			20.5	44	8.6	8.7	
3844.0			20.5	44	8.6	8.7	
3846.0	60.3	298	20.6	44	8.6	8.7	D
3848.0			20.6	44	8.6	8.7	
3850.0			20.6	44	8.6	8.7	
3852.0			20.6	44	8.6	8.7	
3854.0	62.5	297	20.6	44	8.6	8.7	D
3856.0	64.2	297	20.6	44	8.6	8.7	D
3858.0			20.6	44	8.6	8.7	
3860.0			20.7	45	8.6	8.7	
3862.0			20.7	44	8.6	8.7	
3864.0			20.7	44	8.6	8.7	
3866.0			20.7	44	8.6	8.7	
3868.0			20.7	44	8.6	8.7	
3870.0			20.8	43	8.6	8.7	
3872.0			20.8	43	8.6	8.7	
3874.0			20.8	43	8.6	8.7	
3876.0			20.8	43	8.6	8.7	
3878.0			20.8	43	8.6	8.7	

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3720.0			19.4	48	8.6	8.7	
3722.0	47.3	253	19.5	48	8.6	6.7	D
3724.0	45.0	257	19.5	48	8.6	8.7	D
3726.0			19.5	48	8.6	8.7	
3728.0	47.4	268	19.5	47	8.6	8.7	D
3730.0			19.5	47	8.6	8.7	
3732.0			19.5	47	8.6	8.7	
3734.0	47.8	261	19.5	47	8.6	8.7	D
3736.0	44.7	262	19.5	47	8.6	8.7	D
3738.0	26.1	287	19.6	47	8.6	8.7	D
3740.0	25.9	287	19.6	47	8.6	8.6	D
3742.0			19.6	47	8.6	8.7	
3744.0			19.6	48	8.6	8.7	
3746.0			19.7	48	8.6	8.7	
3748.0			19.7	47	8.6	8.8	
3750.0			19.7	47	8.6	8.8	
3752.0			19.7	47	8.6	8.8	
3754.0			19.7	47	8.6	8.7	
3756.0			19.6	46	8.6	8.7	
3758.0			19.6	47	8.6	8.7	
3760.0			19.6	47	8.6	8.6	
3762.0			19.7	46	8.6	6.6	
3764.0			19.7	45	8.6	8.6	
3766.0			19.8	45	8.6	8.6	
3768.0			19.8	46	8.6	8.6	
3770.0			19.8	46	8.6	8.7	
3772.0			19.9	46	8.6	8.7	
3774.0			19.9	47	8.6	8.7	
3776.0			19.9	46	8.6	8.7	
3778.0			19.9	46	8.6	8.7	
3780.0			19.9	46	8.6	8.7	
3782.0			19.9	46	8.6	8.7	
3784.0			19.9	46	8.6	8.7	
3786.0			19.9	46	8.6	8.7	
3788.0			20.0	46	8.6	8.7	
3790.0			20.0	46	8.6	8.7	
3792.0			20.0	46	8.6	8.6	
3794.0			20.0	45	8.6	8.6	
3796.0	9.4	264	20.0	44	8.6	8.7	D
3798.0	13.7	256	20.0	44	8.6	8.6	D

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3640.0			19.2	49	8.6	8.7	
3642.0			19.2	48	8.6	8.7	
3644.0			19.2	49	8.6	8.7	
3646.0			19.2	49	8.6	8.7	
3648.0			19.2	49	8.6	8.7	
3650.0			19.2	49	8.6	8.7	
3652.0			19.2	49	8.6	8.7	
3654.0			19.2	50	8.6	8.7	
3656.0	32.8	294	19.3	50	8.7	8.7	D
3658.0	29.8	292	19.3	49	8.7	8.7	D
3660.0			19.3	48	8.6	8.7	
3662.0			19.3	49	8.6	8.7	
3664.0			19.3	49	8.6	8.7	
3666.0	19.2	63	19.3	48	8.6	8.7	D
3668.0	21.1	48	19.3	49	8.6	8.7	B
3670.0			19.3	49	8.6	8.7	
3672.0			19.3	49	8.6	8.7	
3674.0	20.5	49	19.3	49	8.6	8.7	B
3676.0	21.2	51	19.3	48	8.6	8.7	D
3678.0	29.5	71	19.3	48	8.6	8.7	D
3680.0	19.9	58	19.3	48	8.6	8.7	D
3682.0			19.3	48	8.6	8.7	
3684.0			19.3	48	8.6	8.7	
3686.0			19.3	48	8.6	8.7	
3688.0			19.3	49	8.6	8.7	
3690.0			19.3	48	8.6	8.7	
3692.0	37.7	247	19.3	48	8.6	8.6	D
3694.0			19.3	48	8.6	8.6	
3696.0	37.0	252	19.3	48	8.5	8.7	B
3698.0	35.3	252	19.3	47	8.5	8.7	D
3700.0	37.7	253	19.3	47	8.6	8.7	D
3702.0	40.9	255	19.3	48	8.5	8.7	D
3704.0			19.4	48	8.5	8.7	
3706.0			19.4	47	8.6	8.7	
3708.0			19.4	47	8.6	8.7	
3710.0			19.4	48	8.6	8.7	
3712.0			19.4	48	8.5	8.6	
3714.0	40.8	253	19.4	47	8.6	8.6	B
3716.0	39.0	253	19.4	48	8.6	8.6	D
3718.0			19.4	48	8.6	8.6	

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3560.0			18.8	48	8.7	8.8	
3562.0			18.8	48	8.7	8.9	
3564.0			18.9	50	8.8	9.0	
3566.0			18.9	54	8.8	9.0	
3568.0			18.9	56	8.7	8.9	
3570.0			18.9	56	8.7	8.9	
3572.0			18.9	56	8.8	9.0	
3574.0	52.5	208	18.9	56	8.8	9.0	D
3576.0			18.9	55	8.7	9.0	
3578.0			18.9	54	8.8	9.0	
3580.0			18.9	52	8.7	9.0	
3582.0	85.6	44	18.9	52	8.7	8.9	B
3584.0			18.9	53	8.6	8.8	
3586.0			18.9	52	8.6	8.7	
3588.0			18.9	51	8.6	8.7	
3590.0			18.9	50	8.7	8.7	
3592.0			19.0	50	8.6	8.7	
3594.0			19.0	49	8.6	8.7	
3596.0			19.0	49	8.6	8.7	
3598.0			19.0	48	8.6	8.7	
3600.0			19.0	48	8.6	8.7	
3602.0			19.0	48	8.6	8.7	
3604.0			19.1	48	8.6	8.7	
3606.0			19.1	49	8.6	8.7	
3608.0			19.1	49	8.6	8.7	
3610.0			19.1	49	8.6	8.7	
3612.0			19.1	49	8.6	8.7	
3614.0			19.1	49	8.6	8.7	
3616.0	48.6	256	19.1	49	8.6	8.7	B
3618.0	46.8	256	19.1	49	8.6	8.7	B
3620.0			19.1	49	8.6	8.7	
3622.0			19.2	49	8.6	8.7	
3624.0			19.2	49	8.6	8.7	
3626.0			19.2	48	8.6	8.7	
3628.0			19.2	49	8.6	8.7	
3630.0			19.2	49	8.6	8.7	
3632.0			19.2	49	8.6	8.7	
3634.0			19.2	49	8.6	8.7	
3636.0			19.2	49	8.6	8.7	
3638.0			19.2	49	8.6	8.7	

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3480.0			18.3	49	8.6	8.7	
3482.0			18.3	49	8.6	8.7	
3484.0			18.3	50	8.6	8.8	
3486.0			18.3	50	8.6	8.8	
3488.0			18.3	50	8.6	8.8	
3490.0			18.4	50	8.6	8.8	
3492.0			18.4	50	8.6	8.8	
3494.0			18.4	50	8.7	8.9	
3496.0			18.4	50	8.8	9.0	
3498.0			18.4	50	9.0	9.1	
3500.0			18.4	49	8.9	9.0	
3502.0			18.4	49	8.7	8.9	
3504.0			18.4	49	8.7	8.9	
3506.0			18.5	49	8.6	8.9	
3508.0			18.5	50	8.6	8.8	
3510.0			18.5	50	8.6	8.8	
3512.0			18.5	50	8.6	8.8	
3514.0			18.5	49	8.6	8.8	
3516.0			18.5	48	8.6	8.8	
3518.0			18.5	50	8.6	8.8	
3520.0			18.5	51	8.6	8.8	
3522.0			18.6	51	8.6	8.8	
3524.0			18.6	51	8.6	8.8	
3526.0			18.6	50	8.6	8.8	
3528.0			18.6	50	8.6	8.8	
3530.0	23.6	351	18.6	50	8.6	8.8	D
3532.0			18.6	51	8.6	8.8	
3534.0			18.6	50	8.7	8.9	
3536.0			18.6	50	8.7	8.9	
3538.0			18.6	51	8.7	8.9	
3540.0	24.5	3	18.6	52	8.7	8.9	D
3542.0	27.0	360	18.6	53	8.6	8.8	D
3544.0			18.6	53	8.7	8.9	
3546.0			18.6	52	8.6	8.8	
3548.0			18.6	50	8.6	8.8	
3550.0			18.7	47	8.6	8.8	
3552.0			18.7	47	8.7	8.8	
3554.0			18.7	48	8.7	8.8	
3556.0			18.7	48	8.6	8.8	
3558.0			18.8	48	8.7	8.8	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	DIAM 1-3	DIAM 2-4	QUAL. INDEX BEST =A
3400.0			17.6	51	9.4	8.9	
3402.0			17.6	52	9.0	8.8	
3404.0			17.6	51	8.8	8.8	
3406.0	66.7	360	17.6	52	8.7	8.8	D
3408.0			17.6	51	8.7	8.8	
3410.0	72.5	360	17.7	51	8.7	8.8	D
3412.0			17.7	51	8.7	8.8	
3414.0			17.7	51	8.7	8.7	
3416.0			17.7	51	8.7	8.7	
3418.0			17.7	51	8.7	8.8	
3420.0			17.7	51	8.7	8.8	
3422.0			17.7	51	8.7	8.8	
3424.0	29.7	17	17.8	51	8.6	8.8	B
3426.0			17.8	51	8.5	8.8	
3428.0			17.8	51	8.6	8.7	
3430.0			17.8	50	8.6	8.7	
3432.0			17.8	50	8.6	8.7	
3434.0	25.5	12	17.8	50	8.7	8.7	D
3436.0	30.8	26	17.9	50	8.7	8.8	D
3438.0	28.7	22	17.9	50	8.7	8.8	D
3440.0	25.0	26	17.9	50	8.7	8.7	D
3442.0			17.9	50	8.6	8.7	
3444.0			17.9	51	8.6	8.7	
3446.0	50.0	120	17.9	51	8.7	8.8	D
3448.0	52.0	114	17.9	51	8.7	8.8	D
3450.0	51.4	117	17.9	50	8.7	8.8	D
3452.0			17.9	50	8.6	8.8	
3454.0			18.0	51	8.6	8.8	
3456.0			18.0	51	8.6	8.8	
3458.0			18.0	50	8.6	8.7	
3460.0			18.0	49	8.7	8.7	
3462.0			18.1	49	8.7	8.8	
3464.0			18.1	49	8.7	8.8	
3466.0			18.1	49	8.7	8.8	
3468.0			18.1	49	8.7	8.8	
3470.0	26.5	285	18.1	49	8.6	8.8	D
3472.0			18.1	50	8.6	8.8	
3474.0	31.4	283	18.2	50	8.6	8.7	D
3476.0	31.6	280	18.2	49	8.6	8.7	B
3478.0			18.2	49	8.6	8.7	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3320.0			17.1	52	8.7	8.9	
3322.0			17.1	52	8.7	9.0	
3324.0			17.1	52	8.7	8.9	
3326.0			17.1	52	8.7	8.9	
3328.0			17.1	51	8.7	8.9	
3330.0			17.2	51	8.7	8.9	
3332.0			17.2	51	8.7	8.9	
3334.0			17.2	51	8.7	8.9	
3336.0			17.2	51	8.7	8.9	
3338.0			17.3	52	8.7	8.9	
3340.0			17.3	52	8.7	8.9	
3342.0			17.3	52	8.8	9.0	
3344.0			17.3	52	8.8	9.0	
3346.0			17.3	52	8.8	9.0	
3348.0			17.3	52	8.7	9.0	
3350.0			17.3	51	8.7	9.0	
3352.0			17.3	51	8.7	9.1	
3354.0			17.3	52	8.8	9.1	
3356.0			17.3	52	8.8	9.1	
3358.0	44.1	278	17.3	52	8.8	9.0	B
3360.0	45.0	276	17.4	51	8.8	9.0	B
3362.0	46.4	266	17.4	51	8.7	8.9	D
3364.0			17.4	52	8.7	8.9	
3366.0	22.6	287	17.4	51	8.7	8.9	D
3368.0	32.1	308	17.4	51	8.7	8.9	D
3370.0			17.5	51	8.7	8.9	
3372.0			17.5	52	8.7	8.9	
3374.0			17.5	52	8.7	8.9	
3376.0			17.5	52	8.7	8.9	
3378.0			17.5	52	8.7	8.9	
3380.0	29.8	292	17.5	52	8.8	8.9	D
3382.0			17.6	52	8.8	8.9	
3384.0			17.6	52	8.8	8.9	
3386.0			17.6	52	8.7	8.8	
3388.0			17.6	52	8.7	8.8	
3390.0			17.6	52	8.8	8.8	
3392.0			17.6	52	8.8	8.8	
3394.0			17.6	52	8.8	8.9	
3396.0			17.6	51	8.8	9.0	
3398.0			17.6	51	8.9	9.0	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3240.0			16.7	51	8.7	8.8	
3242.0			16.7	51	8.8	8.8	
3244.0			16.7	52	8.8	8.7	
3246.0			16.7	52	8.8	8.7	
3248.0			16.7	52	8.8	8.7	
3250.0			16.7	52	8.7	8.7	
3252.0			16.7	52	8.7	8.7	
3254.0			16.7	52	8.7	8.7	
3256.0			16.7	52	8.7	8.7	
3258.0	64.6	243	16.7	52	8.8	8.8	D
3260.0	64.0	244	16.7	52	8.8	8.8	B
3262.0			16.7	52	8.7	8.8	
3264.0			16.7	51	8.7	8.8	
3266.0			16.7	51	8.7	8.8	
3268.0			16.7	52	8.7	8.8	
3270.0			16.7	52	8.7	8.8	
3272.0			16.7	51	8.7	8.8	
3274.0			16.8	51	8.7	8.8	
3276.0			16.8	51	8.7	8.8	
3278.0			16.9	51	8.7	8.8	
3280.0			16.9	51	8.7	8.9	
3282.0			16.8	51	8.7	8.8	
3284.0			16.8	50	8.7	8.8	
3286.0			16.8	50	8.7	8.8	
3288.0			16.8	51	8.7	8.8	
3290.0			16.9	50	8.7	8.8	
3292.0			16.9	50	8.7	8.8	
3294.0			16.9	50	8.7	8.8	
3296.0			16.9	51	8.7	8.8	
3298.0			16.9	51	8.7	8.8	
3300.0			16.9	51	8.7	8.9	
3302.0			17.0	51	8.7	8.9	
3304.0			17.0	51	8.7	8.9	
3306.0			17.0	51	8.8	8.9	
3308.0			17.0	51	8.8	8.9	
3310.0			17.0	51	8.8	8.9	
3312.0			17.0	51	8.7	8.9	
3314.0			17.1	51	8.7	8.9	
3316.0			17.1	51	8.7	8.9	
3318.0			17.1	52	8.7	8.9	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3160.0			16.3	57	8.8	8.7	
3162.0			16.4	56	8.8	8.7	
3164.0			16.4	56	8.8	8.8	
3166.0	70.7	9	16.4	55	8.8	8.8	D
3168.0	78.4	298	16.4	54	8.8	8.8	D
3170.0			16.4	54	8.8	8.7	
3172.0	70.3	295	16.5	55	8.8	8.7	D
3174.0			16.5	55	8.8	8.8	
3176.0			16.5	55	8.8	8.9	
3178.0			16.5	54	8.8	8.9	
3180.0			16.5	54	8.8	8.8	
3182.0			16.5	54	8.7	8.8	
3184.0			16.5	54	8.7	8.7	
3186.0			16.5	54	8.7	8.7	
3188.0			16.5	54	8.7	8.7	
3190.0	60.1	230	16.5	54	8.7	8.7	B
3192.0			16.5	54	8.7	8.8	
3194.0			16.5	55	8.8	8.8	
3196.0			16.5	56	8.8	8.8	
3198.0			16.5	55	8.7	8.8	
3200.0			16.6	55	8.7	8.8	
3202.0			16.6	53	8.7	8.8	
3204.0			16.6	52	8.7	8.8	
3206.0			16.6	52	8.7	8.8	
3208.0			16.6	52	8.7	8.8	
3210.0			16.6	52	8.7	8.8	
3212.0			16.6	51	8.8	8.8	
3214.0			16.6	51	8.7	8.9	
3216.0			16.6	51	8.8	8.9	
3218.0			16.6	51	8.8	8.9	
3220.0			16.6	50	8.8	8.9	
3222.0			16.6	51	8.7	8.8	
3224.0			16.6	51	8.7	8.8	
3226.0	47.3	284	16.6	51	8.7	8.8	D
3228.0			16.6	50	8.7	8.7	
3230.0			16.7	50	8.7	8.8	
3232.0			16.7	50	8.7	8.8	
3234.0	48.7	287	16.7	51	8.7	8.8	D
3236.0	47.5	287	16.7	51	8.7	8.8	D
3238.0			16.7	52	8.7	8.8	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3080.0			15.8	70	8.6	8.8	
3082.0			15.8	70	8.7	8.8	
3084.0			15.8	72	8.8	8.8	
3086.0			15.8	73	8.8	8.9	
3088.0			15.8	72	8.8	8.8	
3090.0			15.8	72	8.8	8.7	
3092.0			15.8	72	8.9	8.8	
3094.0			15.8	70	8.8	8.8	
3096.0			15.8	69	8.7	8.8	
3098.0			15.8	68	8.8	8.8	
3100.0			15.8	65	8.8	8.8	
3102.0			15.7	60	8.9	8.9	
3104.0			15.7	57	8.8	8.9	
3106.0			15.7	57	8.8	8.9	
3108.0			15.7	58	8.8	8.9	
3110.0			15.8	57	8.8	8.9	
3112.0			15.8	56	8.8	8.9	
3114.0			15.8	54	8.8	8.9	
3116.0			15.8	53	8.8	8.9	
3118.0			15.8	53	8.8	8.9	
3120.0			15.9	53	8.7	8.9	
3122.0			15.9	53	8.8	8.9	
3124.0			15.9	52	8.8	8.9	
3126.0	84.8	28	15.9	51	8.8	8.9	D
3128.0	32.6	305	15.9	51	8.8	8.8	D
3130.0	33.3	311	15.9	51	8.9	8.8	D
3132.0	32.2	314	15.8	51	8.9	8.8	D
3134.0			15.7	50	8.9	8.8	
3136.0			15.6	51	8.8	8.7	
3138.0			15.5	52	9.1	8.7	
3140.0			15.7	52	9.1	8.7	
3142.0			16.1	52	8.7	8.7	
3144.0			16.2	53	8.7	8.7	
3146.0			16.2	55	8.9	8.8	
3148.0			16.2	56	9.0	8.9	
3150.0			16.2	56	8.9	8.8	
3152.0			16.2	56	8.8	8.7	
3154.0			16.2	57	8.7	8.7	
3156.0			16.3	57	8.8	8.8	
3158.0			16.3	57	8.8	8.8	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
3000.0			15.6	55	8.7	8.7	
3002.0			15.6	55	8.7	8.7	
3004.0			15.6	56	8.7	8.7	
3006.0			15.6	55	8.7	8.7	
3008.0			15.6	55	8.7	8.7	
3010.0			15.6	56	8.7	8.7	
3012.0			15.6	56	8.7	8.8	
3014.0			15.6	55	8.7	8.8	
3016.0			15.7	55	8.7	8.8	
3018.0			15.7	54	8.7	8.8	
3020.0			15.7	52	8.8	8.9	
3022.0	65.8	28	15.7	49	8.8	8.9	B
3024.0			15.7	47	8.9	9.0	
3026.0			15.7	50	8.9	9.1	
3028.0			15.7	53	8.9	9.2	
3030.0			15.7	54	8.9	9.2	
3032.0			15.7	53	9.0	9.2	
3034.0			15.7	53	9.0	9.2	
3036.0			15.7	53	8.9	9.2	
3038.0			15.7	53	8.9	9.1	
3040.0			15.7	54	8.9	9.1	
3042.0			15.7	54	9.0	9.2	
3044.0			15.7	54	9.1	9.4	
3046.0			15.8	55	9.3	9.7	
3048.0			15.8	55	9.4	9.8	
3050.0	89.0	302	15.8	55	9.4	9.9	D
052.0	89.3	300	15.8	54	9.4	9.9	D
054.0			15.8	53	9.3	9.6	
056.0			15.9	52	9.0	9.2	
58.0			15.9	51	8.8	8.8	
60.0			16.0	49	8.7	8.7	
2.0			16.0	48	8.6	8.7	
4.0			16.0	50	8.6	8.7	
.0			16.0	57	8.6	8.7	
.0			16.0	62	8.6	8.8	
.0			15.9	66	8.6	8.8	
0			15.8	69	8.6	8.8	
0			15.8	70	8.6	8.8	
0			15.8	69	8.6	8.8	
			15.8	70	8.6	8.8	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
2920.0			15.2	57	8.8	8.8	
2922.0			15.2	57	8.8	8.8	
2924.0			15.2	56	8.8	8.8	
2926.0			15.3	56	8.9	8.8	
2928.0			15.3	56	8.8	8.7	
2930.0			15.3	57	8.8	8.7	
2932.0			15.4	58	8.7	8.7	
2934.0			15.4	60	8.7	8.7	
2936.0			15.4	60	8.7	8.7	
2938.0			15.4	60	8.7	8.7	
2940.0			15.4	59	8.7	8.7	
2942.0			15.4	59	8.8	8.7	
2944.0			15.4	60	8.8	8.7	
2946.0			15.4	60	8.8	8.7	
2948.0			15.4	60	8.8	8.7	
2950.0			15.4	60	8.8	8.7	
2952.0			15.4	60	8.8	8.7	
2954.0			15.4	60	8.8	8.7	
2956.0			15.4	60	8.8	8.8	
2958.0	70.0	116	15.4	59	8.8	8.8	B
2960.0			15.5	58	8.8	8.7	
2962.0			15.5	57	8.8	8.7	
2964.0			15.5	57	8.7	8.7	
2966.0			15.5	56	8.7	8.7	
2968.0			15.6	57	8.8	8.7	
2970.0			15.6	58	8.7	8.7	
2972.0			15.6	58	8.7	8.8	
2974.0			15.6	58	8.8	8.8	
2976.0			15.6	57	8.8	8.8	
2978.0			15.6	57	8.8	8.8	
2980.0			15.6	56	8.8	8.8	
2982.0			15.6	56	8.8	8.8	
2984.0			15.6	57	8.8	8.8	
2986.0			15.6	57	8.8	8.8	
2988.0			15.6	57	8.7	8.8	
2990.0			15.6	57	8.7	8.7	
2992.0			15.6	57	8.7	8.7	
2994.0			15.6	58	8.7	8.7	
2996.0			15.6	58	8.7	8.7	
2998.0			15.6	57	8.7	8.7	

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
2840.0			14.9	67	8.9	8.8	
2842.0			14.9	66	9.0	8.7	
2844.0	25.9	273	14.8	66	9.0	8.7	D
2846.0			14.8	67	8.9	8.7	
2848.0			14.8	66	8.8	8.7	
2850.0	29.3	275	14.9	66	8.9	8.8	B
2852.0	47.5	229	14.9	66	9.0	8.8	D
2854.0	46.7	227	14.9	65	9.1	8.8	B
2856.0	60.3	310	14.9	64	9.2	8.8	D
2858.0	49.4	217	14.9	63	9.2	8.9	D
2860.0	39.8	234	14.9	63	9.2	8.8	D
2862.0			14.9	62	9.2	8.7	
2864.0			14.9	61	9.2	8.7	
2866.0			14.9	60	9.1	8.8	
2868.0			14.9	60	8.9	8.9	
2870.0			14.9	61	8.8	8.9	
2872.0			14.9	61	8.8	9.0	
2874.0			15.0	60	8.7	9.0	
2876.0	27.7	315	15.0	60	8.8	9.0	B
2878.0	31.8	310	15.1	60	9.0	9.0	D
2880.0			15.1	59	9.1	8.9	
2882.0			15.1	59	9.2	8.8	
2884.0			15.0	58	9.2	8.8	
2886.0			15.0	58	9.1	8.7	
2888.0			15.0	56	8.9	8.7	
2890.0			15.0	56	8.8	8.6	
2892.0			15.0	56	8.8	8.7	
2894.0			15.0	56	8.8	8.9	
2896.0			15.0	56	8.8	9.0	
2898.0			15.0	55	8.8	8.9	
2900.0			15.0	55	8.8	9.0	
2902.0			15.1	54	8.8	9.0	
2904.0			15.1	54	8.7	8.9	
2906.0			15.1	55	8.8	8.9	
2908.0			15.1	55	8.8	8.9	
2910.0			15.1	56	8.8	8.8	
2912.0			15.1	56	8.9	8.8	
2914.0			15.1	56	8.9	8.9	
2916.0			15.1	56	8.9	8.9	
2918.0			15.1	57	8.9	8.8	

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	DIAM 1-3	DIAM 2-4	QUAL. INDEX BEST =A
2760.0	15.7	276	15.6	82	8.8	8.6	D
2762.0	15.2	321	15.6	82	8.9	8.6	D
2764.0			15.6	82	8.9	8.6	
2766.0			15.6	82	9.0	8.8	
2768.0			15.6	81	9.1	8.9	
2770.0			15.6	79	9.0	8.9	
2772.0			15.5	78	8.9	8.9	
2774.0			15.5	79	8.8	8.8	
2776.0			15.4	79	8.8	8.9	
2778.0			15.4	79	8.7	9.0	
2780.0			15.4	79	8.7	8.9	
2782.0			15.4	79	8.6	8.8	
2784.0	27.6	329	15.4	79	8.7	8.8	D
2786.0	28.8	325	15.4	80	8.8	8.9	D
2788.0			15.4	80	8.8	9.1	
2790.0			15.4	80	8.9	9.1	
2792.0	23.1	317	15.4	79	8.9	9.0	B
2794.0	17.9	291	15.4	79	8.8	8.9	D
2796.0			15.4	80	8.8	8.8	
2798.0			15.3	80	8.9	8.7	
2800.0			15.2	80	9.1	8.7	
2802.0			15.2	80	9.1	8.9	
2804.0			15.2	80	9.0	8.9	
2806.0			15.2	80	8.9	8.9	
2808.0			15.3	80	9.0	9.0	
2810.0			15.3	79	9.2	9.0	
2812.0			15.4	78	9.1	9.0	
2814.0			15.3	77	9.0	9.1	
2816.0			15.3	75	8.9	9.0	
2818.0			15.3	74	8.8	8.8	
2820.0			15.2	73	8.7	8.9	
2822.0			15.1	72	8.7	9.0	
2824.0			15.0	71	8.6	9.0	
2826.0			15.0	70	8.6	8.9	
2828.0			15.0	70	8.7	9.1	
2830.0	51.5	202	15.1	70	8.7	9.4	D
2832.0	50.7	198	15.1	70	8.8	9.4	D
2834.0			15.0	69	9.0	9.2	
2836.0			15.0	68	9.0	9.1	
2838.0			15.0	68	8.9	8.9	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
2680.0			16.5	96	8.8	8.8	
2682.0			16.4	96	8.8	8.7	
2684.0			16.4	95	8.8	8.7	
2686.0			16.3	93	8.7	8.8	
2688.0	30.5	266	16.3	93	8.6	8.9	B
2690.0	28.9	261	16.3	93	8.6	8.9	B
2692.0			16.3	94	8.6	8.9	
2694.0			16.2	94	8.6	8.9	
2696.0	21.7	336	16.1	94	8.6	8.8	B
2698.0	21.9	318	16.1	93	8.6	8.8	D
2700.0			16.1	93	8.7	8.7	
2702.0			16.0	94	8.7	8.7	
2704.0			16.0	93	8.7	8.7	
2706.0	4.0	311	16.0	93	8.6	8.7	D
2708.0	10.5	339	15.9	92	8.6	8.7	D
2710.0	4.2	326	15.8	90	8.6	8.8	D
2712.0	4.6	327	15.7	90	8.6	8.7	D
2714.0	7.1	322	15.6	90	8.6	8.6	D
2716.0			15.5	90	8.7	8.5	
2718.0			15.4	89	8.7	8.5	
2720.0	22.9	283	15.4	89	8.8	8.5	B
2722.0	22.6	283	15.4	88	8.9	8.6	D
2724.0			15.3	87	9.0	8.7	
2726.0			15.2	86	8.9	8.8	
2728.0			15.2	84	8.9	8.8	
2730.0			15.1	83	8.8	8.8	
2732.0			15.1	83	8.7	8.8	
2734.0			15.2	83	8.7	8.9	
2736.0			15.2	83	8.8	8.9	
2738.0			15.3	84	8.8	8.9	
2740.0			15.4	83	8.8	8.8	
2742.0			15.5	83	8.9	8.8	
2744.0			15.6	83	9.0	8.8	
2746.0	20.0	320	15.7	83	9.0	8.8	D
2748.0	21.3	260	15.8	83	8.9	8.7	D
2750.0	18.2	301	15.8	83	8.8	8.7	D
2752.0	21.7	268	15.8	83	8.8	8.7	D
2754.0	17.2	300	15.7	82	8.8	8.6	B
2756.0			15.6	82	8.7	8.6	
2758.0			15.6	82	8.8	8.6	

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DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
2600.0			17.9	107	9.4	9.9	
2602.0			17.9	107	9.6	9.7	
2604.0			17.9	106	9.5	9.5	
2606.0			17.9	106	9.4	9.9	
2608.0			17.9	105	9.5	10.3	
2610.0			17.8	104	9.6	10.3	
2612.0			17.8	104	9.5	9.9	
2614.0			17.7	104	9.3	9.8	
2616.0			17.7	104	9.2	9.7	
2618.0			17.7	104	9.1	9.7	
2620.0			17.7	104	9.1	9.5	
2622.0			17.6	103	9.1	9.2	
2624.0			17.6	102	9.0	9.2	
2626.0			17.6	101	9.0	9.1	
2628.0			17.5	101	9.0	9.1	
2630.0			17.4	101	9.1	9.1	
2632.0			17.3	101	9.1	9.1	
2634.0			17.3	101	9.0	9.0	
2636.0			17.2	101	8.8	8.9	
2638.0			17.2	101	8.7	8.9	
2640.0			17.1	101	8.8	8.9	
2642.0			17.1	100	9.1	9.0	
2644.0			17.1	100	9.1	9.0	
2646.0			17.1	100	9.0	8.9	
2648.0			17.1	100	9.1	9.0	
2650.0			17.0	100	9.1	8.9	
2652.0			17.0	99	9.1	8.9	
2654.0			16.9	100	9.1	8.9	
2656.0			16.8	99	9.1	8.8	
2658.0			16.7	99	8.9	8.8	
2660.0			16.7	98	8.8	8.7	
2662.0			16.7	98	8.7	8.6	
2664.0			16.6	98	8.8	8.6	
2666.0			16.6	98	9.0	8.7	
2668.0			16.6	98	9.0	8.7	
2670.0			16.5	98	8.7	8.7	
2672.0			16.5	97	8.7	8.7	
2674.0			16.5	96	8.8	8.7	
2676.0			16.5	96	8.8	8.8	
2678.0			16.5	96	8.8	8.8	

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UNION GEOTHERMAL CO. OF BACA 20-REDRILL-1 PAGE 1-FILE 1

DEPTH	FORMATION DIP	FORMATION DIP AZI.	BOREHOLE DEV.	BOREHOLE DEV. AZI.	BOREHOLE DIAM 1-3	BOREHOLE DIAM 2-4	QUAL. INDEX BEST =A
2520.0			17.6	109	8.8	8.9	
2522.0			17.6	108	8.8	8.9	
2524.0			17.7	107	8.7	8.8	
2526.0			17.7	108	8.8	8.9	
2528.0			17.7	108	8.8	8.9	
2530.0			17.7	108	8.8	8.8	
2532.0			17.7	107	8.8	8.8	
2534.0			17.7	107	8.8	8.8	
2536.0			17.7	107	8.8	8.7	
2538.0			17.7	107	8.7	8.7	
2540.0			17.7	107	8.7	8.8	
2542.0			17.8	107	8.8	8.7	
2544.0			17.8	107	8.8	8.7	
2546.0			17.8	106	8.7	8.8	
2548.0			17.8	106	8.7	8.8	
2550.0			17.8	105	8.6	8.8	
2552.0			17.9	105	8.6	8.8	
2554.0			17.9	106	8.6	8.8	
2556.0			17.9	106	8.6	8.9	
2558.0			17.9	105	8.6	8.9	
2560.0			17.9	105	8.7	8.8	
2562.0			17.9	106	8.7	8.8	
2564.0			17.9	106	8.7	8.8	
2566.0			17.9	105	8.7	8.7	
2568.0			17.9	104	8.7	8.7	
2570.0			17.9	106	8.7	8.7	
2572.0			17.9	107	8.7	8.6	
2574.0			17.9	107	8.8	8.6	
2576.0			17.9	107	8.8	8.6	
578.0			17.9	107	8.8	8.6	
580.0			17.9	107	8.9	8.6	
582.0			17.9	108	9.1	8.6	
84.0			17.9	109	9.0	8.7	
86.0			17.9	109	9.0	8.7	
8.0			17.9	108	9.0	8.7	
0.0			17.9	109	9.1	8.7	
2.0			17.9	108	9.4	8.7	
.0			18.0	107	9.4	8.7	
.0			18.0	107	9.2	8.9	
.0			17.9	108	9.2	9.5	

Schlumberger

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HIGH RESOLUTION

DIPMETER

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CLUSTER LISTING
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UNION GEOTHERMAL CO. OF N.M

REDONDO CREEK

SANDOVAL, NEW MEXICO

BACA 20-REDRILL-1

RUN NO. THREE JOB NO. 14011

CLUSTER RESULTS ONLY

4 FT. CORR. - 2 FT. STEP

40 DEG. X2 SEARCH ANGLE

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