GL04384

LOCATION AND CHARACTERISTICS
OF A
HIGH TEMPERATURE STEAM RESERVOIR
NORTHWEST GEYSERS
SONOMA COUNTY, CALIFORNIA

CONFIDENTIAL

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SUMMARY

A high temperature steam reservoir underlies a small part of the Power Plant Area A-1 leases, most of Area A-2 and a large but unknown portion of Area 3. The areal extent of this reservoir is shown on Figure 1. The high temperature reservoir is defined by flowing fluid temperatures exceeding 500°F, rock temperatures commonly exceeding 600°F and steam enthalpies about 1320 BTU/lb. The high temperature reservoir is detected during well drilling by temperature measurements, and after drilling by downhole logging and wellhead measurements. Most wells that penetrate the high temperature reservoir produce more gas and higher enthalpy steam than from the "typical" (475°F and 1240 BTU/lb.) vapor-dominated reservoir in the Northwest Geysers area.

Steam from the existing GEOOC wells is produced from both a "typical" Geysers reservoir and the high temperature reservoir. In all cases, the high temperature reservoir is in the lower portion of the wells and is overlain by a "typical" Geysers reservoir. The high temperature reservoir is estimated to contribute less than 10% of the drilled steam flow from Area A-1, approximately one-quarter of the tested flow from Area A-2, and almost one-half from Area 3.

The thinnest portion of the "typical" reservoir is in the vicinity of Prati 32, 37, 39 and Prati State 31. These wells also have both the highest wellhead enthalpies and highest H_2S concentrations. Here the contribution from the high temperature reservoir is greater relative to the "typical" reservoir.

Depth to the high temperature reservoir is relatively uniform and varies about an average of -5900 subsea. The depth to the high temperature reservoir is less variable than the top of steam of the overlying "typical" reservoir.

The hydrogen sulfide (H_2S) and carbon dioxide (CO_2) concentrations of steam in the Northwest Geysers do not vary primarily as a function of depth. Rather, the largest variance is a result of whether or not the high temperature reservoir is penetrated. GEOOC wells penetrating only the "typical" reservoir produce H_2S in the range of 250-800 ppmw. The calculated H_2S concentration of the high temperature reservoir is estimated in the range of 1000-3500 ppmw. The total H_2S concentration of the high temperature wells therefore is primarily a function of the contribution of high temperature steam entering the wells and varies between 800 and 2000 ppmw as measured at the wellhead.

There are no identified lithologic or mineralogic conditions that separate the high temperature reservoir from the "typical" reservoir, although the two reservoirs are quite distinct and can be located in most wells to ±200' by temperature measurements.

The rock of both steam reservoirs and the unfractured "cap rock" is almost entirely massive graywacke turbidite beds and intervals of thin-bedded graywacke turbidites intercalated with siltstone and shaley argillite. The secondary vein mineralogy of the "typical" and high temperature reservoirs are not diagnostic of either, and the overall abundance in both is low, usually 1-3% of the total rock. Although the graywacke of the high temperature reservoir is altered to a biotite-tourmaline hornfels, the deeper portions of some wells in the "typical" reservoir are also hornfelsic. The thermal conductivity of the hornfelsic graywacke in the high temperature reservoir was measured and found to be very similar to graywacke values from anywhere else in The Geysers region.

Gas vents, thermal springs, and hydrothermally altered surface rocks are relatively rare in the Northwest Geysers area compared to other portions of The Geysers field. This portion of The Geysers field evolved more slowly because of its poor connection with the surface. The boundary between the high temperature reservoir and "typical" reservoir is therefore thought to be a thermodynamic feature only, resulting from recent deep boil-down of a liquid-dominated system where conduction is still an important component of heat transfer. Gas concentration of the steam in the Northwest Geysers is higher than elsewhere in The Geysers because of the poor surface connection to the reservoir and as a result of recent boil-down.

Pressure data from the high temperature reservoir are not analyzed in this report. An assumption implicit in the model of reservoir evolution is that the "typical" and high temperature reservoirs are hydrologically connected. Although this assumption is unproven as yet, it is based on available static and dynamic measurements that show pressures are subhydrostatic in both reservoirs with no anomalous differences between the two (Drenick, A., May, 1987, Personal Communication). The differences in pressure between the reservoirs appear to vary along a steam density gradient.

CONCLUSIONS AND RECOMMENDATIONS

1. Wells in the Northwest Geysers with the highest concentrations of gas, also tap the high temperature reservoir at an average depth of -5900'± s.s. If high gas concentrations become a problem to power plant operation, they can be initially avoided in large measure by simply not drilling into, or producing from, the high temperature reservoir. This solution is offset by the loss of steam reserves in the high temperature reservoir and the expectation that gas concentrations may increase with

time as the "typical" reservoir is produced. Therefore, the presence of the high temperature reservoir is another one of the economic determinants of how deep a well is to be drilled in some areas of the Northwest Geysers.

2. A high temperature reservoir has not been produced in The Geysers, except perhaps from the MCR Cobb Valley steam field. Consequently, the performance and decline of the high temperature reservoir cannot be adequately predicted. Those wells receiving 50% or more of their flow from the high temperature reservoir (e.g. Prati 37, 39, and 50) should be monitored closely for atypical reservoir decline. These data may be particularly important to the development of Area 3 where almost one-half of the proven reserves are estimated to be from the high temperature reservoir.

3. Most existing data for the high temperature reservoir were collected at the wellhead and are measurements of a mixture of steam from both the high temperature and the "typical" reservoirs. Direct measurements of the high temperature reservoir should be made in the existing wells including temperature-pressure-spinner logs and downhole geochemical samples. Downhole logs should also be made perdiodically, once wells begin permanent, full time production.

4. There are, apparently, no physical barriers separating the "typical" and high temperature reservoirs. However, cores of rock should be taken and tested to determine if the porosity-permeability structure of the whole rock is a factor in the location of the high temperature reservoir.

BACKGROUND INFORMATION

INTRODUCTION

The presence of high temperatures (>600^{o}F) in GEOOC wells in the Northwest Geysers was first recognized in 1982 from thermometer data taken on directional surveys during the drilling of Prati 7. Upon completion and logging of Prati State 31 in January 1984, the presence of flowing high temperature (>656^{o}F) steam was recorded. Since then, recognition of a high temperature steam reservoir under GEOOC leases in the Northwest Geysers has evolved.

Wells offsetting GEOOC leases also penetrate (a) high temperature reservoir(s). Between 1982 and 1984, Union Oil Company drilled at least three high temperature wells in High Valley with two having recorded temperatures near, or exceeding, 700^{o}F. The data from these wells are owned by GEOOC by virtue of several data trades with Union. Recently it was disclosed to GEOOC during negotiations for a joint corrosion study with Union, that there are also high temperature wells on Union's L'Esperance lease (Robinson, J. P., 1987). In addition, Union Oil believes that the MCR Cobb Valley wells tap, at least in part, a high temperature reservoir.

Whether or not GEOOC, Union and MCR wells tap a common high temperature reservoir or separate reservoirs is unknown and not a topic of this report. Because there are at least two deep (±10,000') wells (Binkley Ranch Unit 1 and Prati 27) that do not encounter high temperatures between the GEOOC and Union high temperature wells, the GEOOC high temperature reservoir is treated in this report as if it were separate.

Wells penetrating the high temperature reservoir, hereinafter referred to as high temperature wells, are the subject of three GEOOC papers referenced in this report. Andy Drenick discussed the logging and interpretation of Prati 39 in his paper given at the Stanford Reservoir Workshop. Jill Haizlip sampled some of the wells in question for stable isotope composition and noted anomalous concentrations in her paper given to the Geothermal Resources Council. Jeff Sternfeld studied the secondary mineralogy of the GEOOC wells and reported a hornfelsic graywacke and its relationship to high temperature wells in his internal GEOOC report memorandum.

The purpose of this report is to describe the location and characteristics of the high temperature reservoir drilled by GEOOC. This report will show that the temperature, enthalpy and H_2S concentrations of steam from the high temperature reservoir are significantly different than the "typical" Geysers reservoir steam. Because the contribution of high temperature steam to some wells is significant, operation of the Coldwater Creek steam field, as well as any future development of Area 3, may be affected by the operation of wells penetrating the high temperature reservoir.

GEOLOGIC SETTING

Lithology

The subsurface lithology is summarized as a column in Figure 2. Many GEOOC wells in the Northwest Geysers are drilled from the surface to total depth in Franciscan graywacke. Graywacke constitutes both the unfractured cap and the reservoir rocks penetrated by all wells in the Northwest Geysers. The only punctuations of the graywacke are occasional, thin (usually less than 100') units of greenstone and chert, and tectonic-related melanges which include serpentine, blueschist and clay.

Cretaceous and Tertiary tectonism of the area has left a metamorphic signature on much of the graywacke throughout the region. This metamorphism is evidenced by certain minerals (blue schist facies) and a textural fabric which varies from non-foliated graywacke to foliated schist. The graywacke penetrated by GEOOC's wells in the Northwest Geysers is primarily non-foliated, except within melange units.

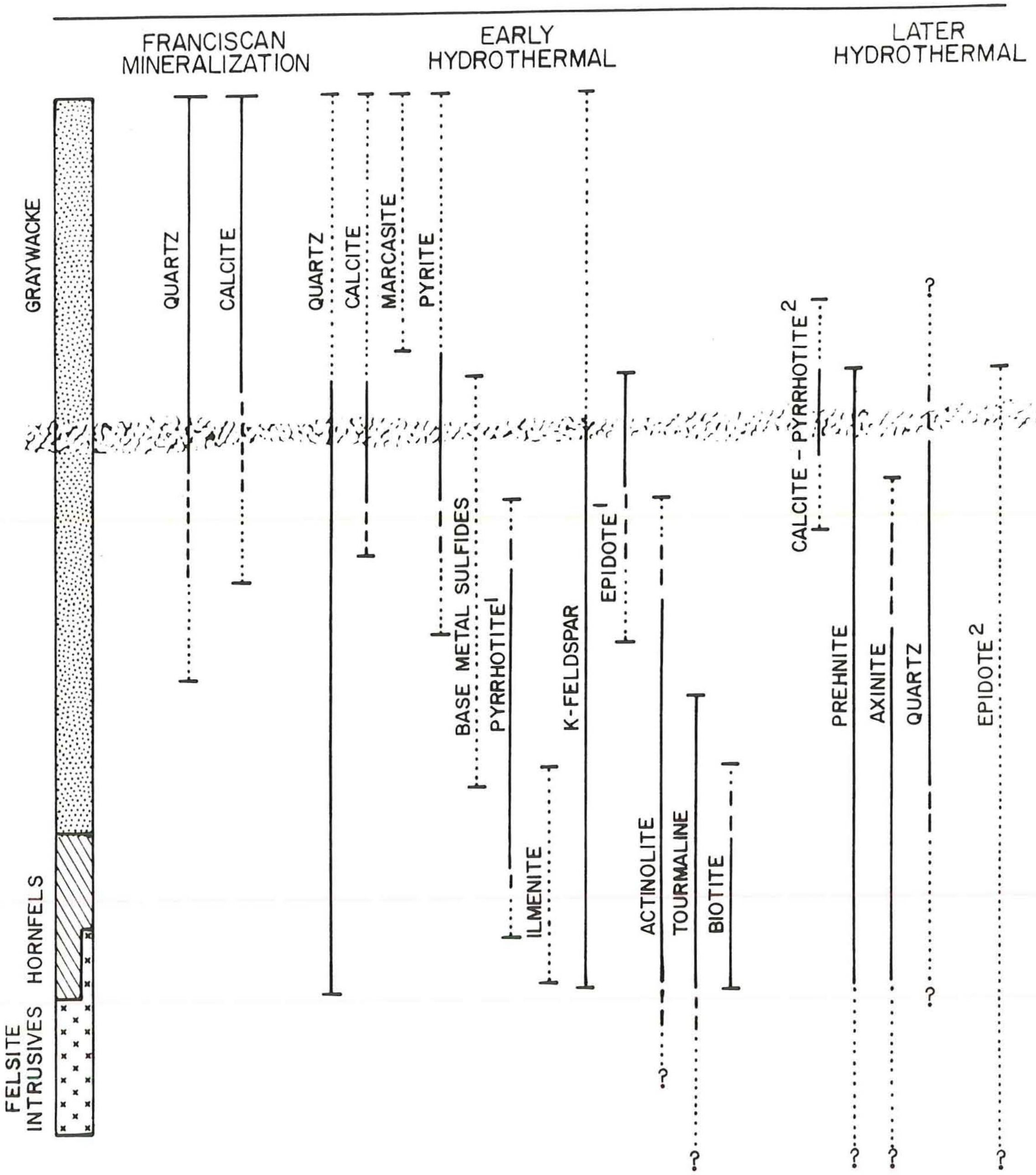
No general lithologic differences are observable between the graywacke of the "typical" and high temperature reservoirs. At one time, the hydrothermal alteration of the reservoir graywackes studied by binocular microscope was confused with a tectonic fabric. However, thin section petrography has since proven that the graywacke in both reservoirs is relatively unmetamorphosed except for Quaternary hydrothermal alteration.

Graywackes in both cores and drill cuttings from GEOOC wells are submarine fan deposits. Massive, poorly graded graywackes, grading from fine to medium grained, occur in sequences often many hundred of feet thick. These massive graywackes are predominant. Thin-bedded graywacke turbidites interbedded with shaley argillite and siltstone constitute the remainder.

A large percentage of steam entries occur in the massive graywacke sequences. Observations from cores indicate that many fractures do not propogate through the shaley argillite sequences; consequently, steam entries may be preferentially located in the massive graywacke units as opposed to the argillite-rich melange and thin-bedded graywacke sequences.

GENERALIZED

SECONDARY MINERALOGY AT THE GEYSERS, CALIFORNIA



TOP OF STEAM

DECREASING RELATIVE ABUNDANCE

GEO OPERATOR CORPORATION
SANTA ROSA, CALIFORNIA

SECONDARY MINERALOGY

FIGURE 2

AUTHOR: JNS **DATE: 5-5-87**

At a depth of about -6000' subsea in most high temperature wells and in some wells penetrating the "typical" reservoir, the graywacke becomes hornfelsic. The hornfelsic graywacke is recognized by its sucrosic texture and reddish-brown ("root beer") color. The color is distinctive and not to be confused with hematite or some of the other iron oxides. Tourmaline and biotite disseminated throughout the graywacke give the hornfels its distinctive color. With increasing depth, the hornfelsic graywacke becomes increasingly recrystallized and sucrosic.

Hornfels facies rocks are generally formed by thermal (contact) metamorphism at temperatures ranging from "250°C to 800°C depending upon the distance from the intrusive contact and the source of heat", (A.G.I. Glossary of Geology, 1974). The significant aspects of hornfelsic graywacke to the Northwest Geysers steam field are: higher temperatures once existed in the "typical" reservoir where hornfelsic graywacke is found; the hornfelsic graywacke in the high temperature reservoir could be a direct result of the current thermal regime; and the hornfels indicates intrusive rocks are relatively nearby. Hornfels aureoles around Quaternary felsite intrusions are penetrated by wells in the Southeast Geysers where felsite may be the "basement" rock. However, until several years ago, there was no knowledge about the presence of Quaternary intrusive rocks in the Northwest Geysers area.

The first speculations about the occurrence of Quaternary intrusive rocks beneath The Geysers is found in the literature of 1946 regarding the adjacent mercury mining districts. Union Oil first drilled into intrusive rocks in the early 1970's in the center of The Geysers field and determined that they were related in age and composition to the Quaternary Clearlake Volcanic field. Felsites, as these intrusive rocks are known, are now penetrated by many wells in the Central and Southeast Geysers and the locations known to GEOOC are noted in Figure 3. Only three occurrences are yet known in the Northwest Geysers: two are felsic glass dikes penetrated by Prati 25 and Prati 27; the third is an outcrop near Prati 25. Felsic intrusive rocks are known as far north as Tyler Valley where there is an outcrop dated at 0.85 million years before present by the U.S. Geological Survey. The presence of hornfelsic graywacke in the deeper portions of most of GEOOC's wells indicates that felsite probably underlies a large portion of the Northwest Geysers.

Indirect evidence for Quaternary intrusion of the Northwest Geysers comes from geomorphological studies of the area. Circular anomalies, barbed tributaries and arcuate stream segments, together with the fact that the drainage system is poorly developed despite rugged relief and high rainfall, lead to the following conclusions by Chester Bebber and Associates:

1. Approximately one million years before present, large-scale magmatic intrusions at depth associated with the Clear Lake Volcanic field, produced uplift and tensional faulting in the Northwest Geysers region.

2. The effects of intrusion and uplift completely dominate the geomorphology of the area from at least Pine Mountain near Cloverdale to Cobb Mountain.

3. Creeks in the area are structurally controlled; not by right-lateral strike slip faulting associated with the San Andreas system, but by recent uplift and associated faulting.

Therefore, intrusive felsite is believed to be important in the origin of The Geysers steam field as both a source of heat and a cause of fracturing and faulting.

<u>Secondary Mineralogy</u>

The secondary mineralogy of GEOOC's Northwest Geysers wells is the subject of an on-going petrologic study. It is discussed by J. Sternfeld in a recent report and will be presented in more detail in subsequent reports. A generalized summary is presented in Figure 2 and discussed below.

There are at least three recognized assemblages of secondary minerals at The Geysers as determined by petrologic and isotopic studies. The oldest is associated with the early history of the Franciscan formation and is most commonly present as quartz and calcite veins. A second mineral assemblage is an early stage of zoned hydrothermal mineralization, characteristic of a liquid hydrothermal system rather than the present steam-dominated system. Early stage hydrothermal minerals commonly recognized in GEOOC's Northwest Geysers wells are biotite, tourmaline, actinolite and epidote. The third recognized assemblage of secondary minerals is associated with a later and cooler stage of hydrothermal alteration. The key minerals of the later stage hydrothermal assemblage are prehnite and axinite whose temperatures of formation overlap the present temperatures of both the "typical" and high temperature reservoirs. All three secondary mineral assemblages overlap below the top of steam as illustrated in Figure 2.

Frequently observed secondary minerals in the high temperature reservoir include prehnite, quartz, axinite, tourmaline, biotite, potassium feldspar, actinolite, and epidote. However, none of these minerals are not diagnostic because they are also present in rocks of the "typical" reservoir. This is interpreted to mean that two or more hydrothermal systems have occupied the same reservoir rock over time.

The relative abundance of hydrothermal vein minerals to the total rock in the Northwest Geysers is low throughout the entire length of any well: rarely do vein minerals exceed 10% of the total; occasionally 5% is encountered; but 1-3% is the usual concentration. There are no increases in the concentration of vein minerals above either the "typical" Geysers reservoir, or high temperature reservoir, suggesting that vein minerals do not confine either reservoir. The only generalization about the secondary mineralization of both reservoirs is that it becomes less confined to veins and more pervasive with depth, giving the rock a macroscopic recrystallized texture.

Results from study of the secondary minerals lead to the following conclusions:

1. There are no secondary mineral "caps" confining either the "typical" or high temperature reservoirs.

2. The secondary mineralogy of both reservoirs is essentially the same.

3. The intensity of hydrothermal alteration increases with depth in both reservoirs.

4. The hydrothermal history of both reservoirs is interpreted to be the same.

Surface Geothermal Manifestations

There are presently no known thermal springs in the Northwest Geysers area unlike the Central and Southeast Geysers. A thermal spring in Squaw Creek about 2000 feet east of the Black Oaks hunting camp is reported on a 1975 U.S. Geological Survey map but is recorded nowhere else in the literature. This thermal spring was not located during a 1980-1981 field study of springs for GEOOC and either is intermittent or has since ceased to flow.

Surface hydrothermal alteration is not extensive in the Northwest Geysers. The largest areas of surficial alteration are near mercury mines and prospects. The largest continuous area of surficial alteration near Areas A-1, A-2 and 3 is near the Black Oaks Mine and hunting camp. The Black Oaks Mine produced only 1 or 2 flasks of mercury from cinnabar, according to the property owner Ed Prati.

Most surficial hydrothermal alteration in The Geysers area terminates at shallow depth with the ground water table. This is a result of gases, including hydrogen sulfide and carbon dioxide, mixing with the groundwater to form acids which bleach the rock. A better term for this kind of alteration is solfateric alteration because there is often no evidence for thermal water being responsible for the alteration. As with mercury mines, it is usually not possible to determine if hydrothermal alteration is a result of current and/or past activity unless thermal springs are present.

Figure 3 shows the location of thermal springs, mercury mines and surficial hydrothermal alteration at The Geysers. It is readily apparent from this figure that relatively few surficial geothermal manifestations occur in the Northwest Geysers. Because hydrothermal alteration is often preserved evidence for past geothermal activity, it is concluded that the surficial geothermal manifestations in the Northwest Geysers were also of limited extent in the past as in the present.

Figure 3 also shows the spatial relationship of noncondensible gas in geothermal steam to surficial geothermal manifestations. As discussed later in this report under the section, Conceptual Model, the high gas content in the steam of the Northwest Geysers and relatively few surface manifestations are believed to be directly related.

Presently, the only known venting of noncondensible gases in GEOOC's developed portion of the Northwest Geysers are confined along the traces of the Squaw Creek and Caldwell Ranch faults. Evidence for these gases is from both dry gas vents and springs which have sulfur-fixing bacteria, travertine, and flocculated iron deposits. Anomalous concentrations of sulfate, carbon dioxide, boron and carbonate are measured in the cold springs. But apart from venting gas along faults presumed to extend to reservoir depth, fluid vents above the Northwest Geysers geothermal system are few. Much less noncondensible gas and little thermal fluids have vented from the Northwest Geysers compared to the Central and Southeast Geysers.

RESERVOIR DATA

Temperature Measurements

Recognition of the high temperature steam reservoir is based primarily upon downhole temperature measurements. Temperature measurements therefore are the foundation for this report. Other data such as wellhead enthalpy and H_2S gas concentration are also useful in the recognition of wells penetrating the high temperature reservoir, but are not diagnostic because the numerical values of surface measurements are largely a function of the relative contribution of the high temperature steam to the total flow rate of a well.

Recently, a temperature-pressure-spinner (T-P-S) tool capable of logging temperatures to 650^{o}F became available. This tool offered by Dresser Atlas can provide the most accurate definition of the high temperature reservoir. However, only four T-P-S logs are presently available for wells penetrating the high temperature reservoir.

Three kinds of temperature information are available for most GEOOC wells: flow line temperature (FLT) of the circulating drilling medium; maximum reading thermometer (MRT) measurements made during directional surveys while drilling; and temperature logs made during drilling and following completion of the wells. Available temperature data of these types are assembled and plotted versus depth for all GEOOC and offsetting competitor wells in the Northwest Geysers. The temperature-depth plots for only GEOOC wells are found in Appendix V.

The available temperature-depth data for wells in the Central Geysers were also plotted to develop an empirical understanding of temperature data. These data, together with data published by Union Oil and the California Division of Oil and Gas, are the bases of the following conclusions about temperatures in the "typical" Geysers reservoir:

1. Temperatures on logs from flowing wells consistently measure temperatures in the range of 440-490^{o}F within the reservoir.

2. Temperature-depth plots of MRT values in the "typical" reservoir usually range from 400^{o}F to 450^{o}F with maximum values near 480^{o}F. MRT temperatures exceeding 600^{o}F gave GEOOC its first indication of a high temperature reservoir.

3. FLT values measured while drilling the "typical" reservoir are typically in the range of 210-230°F but may approach 300°F in some cases. The ratio of air to steam, ambient surface air temperatures, and steam depth all cause FLT to vary greatly from well to well.

Using the data developed from wells in the "typical" Geysers reservoir, criteria were established to determine whether or not the high temperature reservoir is penetrated. These were established with the following ranking by importance:

1. Maximum reading thermometer values exceeding 500°F.
2. Flowing steam temperatures exceeding 500°F.
3. Flow line temperatures measurements of more than 300°F.

Taken together, these criteria were used to estimate the depth to the high temperature reservoir for each GEOOC well. These estimates are presented on Table I and are graphically shown on each of the individual temperature-depth plots for the GEOOC wells. Accuracy of the estimates is about ±200' for most wells.

It must be noted that the temperature logs of flowing steam from completed wells often do not accurately show the boundary between the "typical" and high temperature reservoirs. The reason for this is that high temperature steam flowing up the wellbore masks the cooler entries in the "typical" reservoir. As the steam from the high temperature reservoir moves up the well, it is diluted and cooled by steam from the "typical" reservoir, giving the temperature-depth profile a stepped appearance with high gradients over short distances. A good example of this is seen on the temperature-depth plot for Prati 30. Consequently, MRT values collected while drilling wells serve as a better criteria for delineating the high temperature reservoir and are ranked accordingly.

The maximum temperature within GEOOC wells penetrating the high temperature reservoir is not known. Flowing steam temperatures in this reservoir range from 550°F to more than 650°F. The upper limit is not known because neither thermometers nor electric logging tools are available which exceed 650°F. Union Oil has used a temperature sensitive plastic and has recorded temperatures <u>below steam</u> of 700°F to 825°F during directional surveys in High Valley wells FHV 94-25 and HVS 39A-30. Therefore, a maximum temperature in the high temperature steam reservoir may be near 700°F.

TABLE I

WELLS PENETRATING
HIGH TEMPERATURE RESERVOIR
NORTHWEST GEYSERS, CALIFORNIA

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Well Name	Encountered Top of Steam (S.S.)[1]	Estimated Top of High Temperature Reservoir[2] (M.D.)	Estimated Top of High Temperature Reservoir (S.S.)	Well head Elevation (M.S.L.)
Prati 5	-4294'	8470'	-5768'	2553'
Prati 7	-3912'	7990'	-5549'	2303'
Prati 8	-3139'	8250'	-5803'	2177'
Prati 9	-4864'	8900'	-6358'	2176'
Prati 25	-3377'	8280'	-5770'	2347'
Prati 30	-3901'	8410'	-5953'	2303'
Prati State 31	-4641'	7940'	-5598'	2116'
Prati 32	-4682'	8375'	-6171'	2116'
Prati 37	-5040'	8130'	-6110'	1901'
Prati 38	-4146'	8000'	-5965'	1901'
Prati 39	-3696'	8000' (?)	-5344' (?)	2561'
Prati 50	-4169'	10,135'	-6799'	3029'

Notes: 1. S.S. - sub-sea depth using mean sea level as datum.
2. High temperature reservoir is defined as measured fluid and rock temperatures exceeding 500°F.

Results

The areal extent of the high temperature reservoir shown on Figure 1 was determined by examining both GEOOC and offsetting competitor well data. The southern and eastern extent of the known high temperature reservoir is confined by Union wells on Ottoboni ridge and in the Unit 11 field, and GEOOC wells in Area A-1. The area to the west is largely unexplored except for the Aidlin wells which show little evidence for a high enthalpy reservoir. High temperature wells were drilled to the north by Union in High Valley; but because Prati 27 encountered only the "typical" reservoir, it is unknown whether or not the two areas tap the same high temperature reservoir. It is unknown how far the high temperature reservoir may extend to the north, but it could extend across the Clearlake volcanic field. The temperatures of Audrey A-1 near Sulphur Bank Mine and intermediate distance wells such as the Jorgensen-1 and Wilson-1, all exceed 550^{o}F.

Figure 4 was constructed using the depths to the high temperature steam reservoir shown on Table I and directional survey data. The average depth to high temperature steam is 5900' subsea. The gradients between contours of the depth to the top of high temperature reservoir are much lower than the top of "typical" steam. The relatively uniform depths to the top of the high temperature reservoir may be coincidental or may be related to a common factor such as gravity draining.

Division of Oil and Gas open file records for the Units 7, 8, and 11 steam fields show that most of the original wells were drilled to total depths of less than -5000' subsea; only 13 are known to be deeper than -5400' subsea with four of these exceeding -6300' subsea.

The original Union wells surrounding the high temperature steam zone are completed at depths slightly less than the top of the high temperature reservoir. Production of these surrounding wells may contribute to the drainage of a deeper liquid-dominated reservoir by lowering the pressure of the overlying vapor-dominated reservoir, or a high temperature reservoir may underlie the shallower wells of the operating steam fields adjacent to GEOOC leases. If a high temperature reservoir underlies other parts of the developed fields in The Geysers, it is deeper than -7000 subsea because the GEOOC wells in Area A-1 and a few offsetting Union wells such as Binkley Ranch 1 and Ottoboni State 15 extend to this depth and are not known to encounter high temperature fluids. However, the T-P-S log for Prati State 54 shows a rapid increase in temperature and enthalpy below 10,100' M.D. (-7155' s.s.); but no fluids were encountered. Without the presence of fluids, it cannot be determined whether or not Prati State 54 actually penetrates the high temperature reservoir.

The thickness of the "typical" Geysers reservoir overlying the high temperature steam reservoir was computed and is shown as a contoured isopach map, Figure 5. This map is indicative of the relative contribution that the "typical" reservoir makes to wells penetrating the high temperature reservoir. The thinnest part of the "typical" reservoir is in the area of Prati State 31 and Prati 32 and 37. This area is also where the enthalpy and H_2S concentration of the steam as measured at the wellhead are highest (see Table III and IV).

Gas Measurements

GEOOC makes measurements of noncondensible gases during the drilling, and after completion, of its wells. All measurements are made at the wellhead. Consequently, those measurements made after completion represent a weighted average of the noncondensible gas content of the steam delivered to the well by each entry. Gas measurements made when drilling the upper part of a well are more representative of the nearby reservoir than deeper in a well: a sample collected just after drilling the first steam entry will be undiluted by any other steam entry; a sample collected after the second entry will be a combination of two steam entries; and so on to completion. The only way to sample the gas content of individual entries would be to use a downhole sampler, or packers and capillary tubing, which GEOOC has not done.

The H_2S and CO_2 concentration of steam measured by GEOOC's geochemistry group after completion of GEOOC's Northwest Geysers wells is presented in Tables II and III. The wells in these tables are divided into two sets: those not penetrating the high temperature reservoir and those that do, which are listed in Table I. It becomes immediately apparent upon inspection of these tables that wells that penetrate the high temperature reservoir usually produce 2 or 3 times as much carbon dioxide and hydrogen sulfide than those that don't. However, the gas concentrations from the wells penetrating the high temperature reservoir include a mixture of steam from the upper "typical" reservoir. Therefore, the values alone in Table II can be interpreted only to mean that the GEOOC wells with the highest gas concentrations also penetrate the high temperature reservoir.

TABLE II
GAS CONCENTRATION OF STEAM WELLS NOT PENETRATING HIGH TEMPERATURE RESERVOIR

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Well	*Flow Rate (lbs./hr.)	CO_2 (ppmw)	H_2S (ppmw)	Notes
Prati 1A	20,000 (bleed)	10,000		Values from bleeding well with fish
PS-1	116,500	8098	399	Gas averages from April 20-25, 1983 flow test.
Prati 2	58,000	---	252	Exlog values from Sept. 11-13, 1981 flow test.
Prati 4	206,700	17,633	699	Gas averages from Dec. 26, 1985 flow test.
PS-10	152,500	19,683	700	Gas averages from Dec. 6-10, 1983 flow test
PS-24	161,000	8730	620	Gas averages from April 9, 1987 flow test
Prati 27 RD#1	197,800	23,511	877	Gas averages from July 3, 1986 flow test.
PS-54	85,200	8,254	625	Gas averages from June 11, 1987 flow test.
Wildhorse 5	25,000±	---	269	Exlog values from Mar. 2, 1984 flow test.

TABLE III
GAS CONCENTRATION OF STEAM WELLS THAT PENETRATE HIGH TEMPERATURE RESERVOIR

Well	*Flow Rate (lbs./hr.)	CO_2 (ppmw)	H_2S (ppmw)	Notes
Prati 5	118,200	26,800	1000	Gas averages from Mar. 25, 1986 flow test.
Prati 8	63,000	N/A	873	Gas averages from Nov. 26, 1983 flow test.
Prati 9	59,200	28,960	1036	Gas averages from Nov. 18-21, 1983 flow test.
Prati 25	211,100	31,933	1043	Gas averages from May 31, 1986 flow test.
Prati 30	115,000	60,200	1665	Gas averages from March 19, 1984 flow test.
PS-31	147,500	60,500	2010	Gas averages from Jan. 16, 1984 flow test.
Prati 32	187,400	50,491	1841	Gas averages from Dec. 8-10, 1984 flow test.
Prati 37	177,000	31,040	1466	Gas averages from Jan. 20, 1986 flow test.
Prati 38	194,100	11,257	753	Gas averages from March 27, 1987 flow test.
Prati 39	157,000	35,492	946	Gas averages from Sept. 22-24, 1984 flow test.
Prati 50	147,800	24,000	848	Gas averages from May 15, 1987 flow tests.

*Values not normalized.

All H_2S and CO_2 gas data collected by Exlog/Smith during pauses in the drilling of GEOOC's wells were plotted as a function of depth for the high temperature wells and are in Appendix VI. Although H_2S, CO_2, and methane (CH_4) are continously measured while the drill bit is turning, these gases are grossly diluted by the circulating medium, mud or air. The only time mudloggers can make good measurements of gas from the formation is while drilling with air and when the drill string is removed from the hole to change bits ("trip"). In GEOOC's first wells only H_2S was measured during trips. Now, H_2S and CO_2 are routinely measured. Additional H_2S measurements are required because of environmental regulations. Unfortunately, H_2S and CO_2 concentrations are often not available of the upper steam zone because first entries are usually small and the drilling penetration rate is relatively high.

The depths to the high temperature reservoir as determined by temperature-depth data were drawn on the gas-depth plots. The gas data for high temperature steam wells (Prati 5 and 25 are exceptions) fall into two clusters: above the high temperature reservoir boundary, the H_2S concentrations are within the same range as the wells penetrating only the "typical" reservoir with average concentrations being from 450 to 700 ppmw; below the high temperature reservoir boundary, the H_2S concentrations cluster in the range of 1000-2000 ppmw. CO_2 concentrations cluster above and below the high temperature reservoir boundary in the same manner as H_2S. The gas-depth plots for Prati 9 and Prati 30 provide the best examples of how the gas concentrations are distributed between the two reservoirs.

It is concluded from study of the gas-depth plots that the gas concentrations in GEOOC steam from the Northwest Geysers are primarily a function of which reservoir(s) a well penetrates, not depth. Estimates of the H_2S gas concentrations from the high temperature reservoir are derived from mass balance calculations based on downhole enthalpy estimates and are presented in Appendix II. The results of these calculations are that the H_2S concentrations in the high temperature reservoir range from 1000 to 3500 ppmw.

CALCULATING DOWNHOLE ENTHALPY WITH A WELLBORE HEAT LOSS PROGRAM

The purpose of calculating steam enthalpy at reservoir depth is to derive the relative contribution of steam from the "typical" reservoir and high temperature reservoir, given that the steam enthalpies from the two are very different. With a relative contribution of steam known from each reservoir, other parameters such as gas content of the individual reservoirs can be estimated.

Only a few downhole measurements are available to calculate the enthalpy of flowing steam from GEOOC wells in the Northwest Geysers. Two temperature-pressure logs from wells penetrating only the "typical" steam reservoir indicate an enthalpy of 1240 BTU/lb. of the flowing steam. In addition, three temperature-pressure logs made in the high temperature steam reservoir indicate an enthalpy in the range of 1320 BTU/lb. Because GEOOC's high temperature wells produce a combination of steam flow from both a "typical" Geysers reservoir and a high temperature reservoir, the enthalpy of steam is between 1240 and 1320 BTU/lb., depending upon the relative contribution of steam from each reservoir.

Heat in the cap rock above The Geysers reservoir is transferred primarily by conduction. Consequently, the loss of heat from any unit of steam moving between the shallowest steam entry and the surface can be calculated, and will depend primarily upon: the surface area of the wellbore; the thermal conductivities of the casing cement and earth; the gradient between the steam temperature and earth temperature; and the length of time the steam has been flowing. If the heat loss is calculated, then the downhole enthalpy can be calculated from wellhead enthalpy. Lacking temperature-pressure-spinner information for most wells, it was decided to develop a computer program which would make the numerous calculations needed to estimated the reservoir enthalpy of the steam based on well head measurements.

GEOOC made numerous thermal conductivity measurements of the reservoir rocks and completed intermediate-depth temperature gradient holes in the reservoir cap rock. Given this information, together with surface test data and casing program information, the heat loss from flowing steam in a well at any given depth may be calculated.

A wellbore heat loss computer program was developed from a modified method by Drenick (1986) using transient heat conduction function values, f(t), calculated by Willhite (1967). Appendix I tabulates the inputs and equations of the program. The line source solution typically used to calculate f(t), provided consistently underestimated results when compared to known values. Useful results from line source solutions are found if flow times are one week or more. Most of GEOOC's flow tests for wells in the Northwest Geysers are typically periods of 8 hours and these wells have not been produced except during tests. Consequently, f(t) values for short times based on a radiation boundary model by Willhite were used and found to be meaningful when compared to known values.

The wellbore heat loss program calculates the heat loss for each of the cased and uncased segments of the well above the first steam entry. The summation of all the heat lost between the wellhead and first steam entry, added to the surface enthalpy, provides an estimate of the enthalpy at the first steam entry. The enthalpy is not calculated below the first entry because heat transfer in the reservoir is dominated by convection. Therefore, heat losses of steam from the high temperature reservoir to rocks in the "typical" reservoir are not included.

Results from the wellbore heat loss program agree well with the temperature-pressure-spinner (T-P-S) measurements where they are available. The comparitive results for five of these wells, Prati State 10, Prati State 24, Prati 39, Prati 50, and Prati State 54 are presently in Table IV. A sixth T-P-S log available for comparison is from Union Oil Binkley State 1; measured enthalpy is 1320 BTU/lb and calculated enthalpy is 1340 BTU/lb from a 1.75 hour rig test.

Wellhead measurements made under less than full flow conditions are not useful in determining the presence of the high temperature reservoir. Under choked flow, downhole back-pressure may prevent flow of the high temperature reservoir, which is in the lower portion of any of the wells, into the wellbore. Experience with Prati 5 provides an example.

A T-P-S log of Prati 5 was run with a 1" choke. The measured temperature and pressure at the first steam entry were 458^{o}F and 409 psia, respectively, giving an enthalpy of 1213 BTU/lb. No evidence of a high temperature reservoir is evident during this test. The well was also logged using a single temperature tool under higher flowing conditions (two - 2" vents) giving a measured temperature of 514^{o}F at the first steam entry. Using the heat loss program and wellhead data from full flow conditions, the calculated temperature is 516^{o}F, pressure 202 psia and enthalpy 1277 BTU/lb. No T-P-S log of the well under full-flow conditions is available to verify the calculated enthalpy but the temperature match is indicative that the calculated results are valid.

The T-P-S logging experience with Prati 5 has several implications:

1. Static temperature and pressure logs may not detect a high temperature reservoir because shut-in pressure will prevent the flow of steam into the wellbore.

2. Chemistry measurements must be made with the well completely open to get representative values of the combined reservoir contributions.

TABLE IV
STEAM ENTHALPY[1]
NORTHWEST GEYSERS, CALIFORNIA

Well in "Typical" Geysers Reservoir[2]

Name	Wellhead Enthalpy	Calculated Enthalpy @ First Entry[3]	Flow Rate
Prati State 1	1188 BTU/lb.	1211 BTU/lb.	130,900#/hr.
Prati 2	1195	1251	54,450
Prati 4	1211	1242	205,300
Prati State 10	1202	1229 (Measured: 1231)	103,900
Prati State 24	1215	1248 (Measured: 1250)	161,000
Prati State 27	1202	1227	199,000
Prati State 54	1205	1252 (measured: 1251)	85,200

Wells Penetrating Both "Typical" and High Temperature Reservoirs

Name	Wellhead	Calculated Enthalpy @ First Entry	Flow Rate	Calculated[4] High Temp. Reservoir Contribution
Prati 5	1217 BTU/lb.	1278 BTU/lb.	118,200 lb./hr.	48%
Prati 8	1192	1261	60,853	26%
Prati 9	1194	1255	59,200	19%
Prati 25	1224	1252	211,100	15%
Prati State 31	1231	1285	146,300	56%
Prati 32	1258	1291	187,700	64%
Prati 37	1242	1285	177,000	56%
Prati 38	1200	1242	194,000	3%
Prati 39	1220	1265 (measured: 1275)	159,000	31% (measured: 50%)
Prati 50	1210	1289 (measured: 1281)	147,800	61% (measured: 66%)

Notes:

1. Enthalpy calculated during full flow conditions.
2. Measured fluid and rock temperatures are less than 500°F.
3. "Measured" enthalpies are from simultaneous temperature and pressure values taken at the depth of the first steam entry under full flowing conditions.
4. Calculated values are from mass balance equations using 1240 BTU/lb. for the "typical" Geysers steam reservoir and 1320 BTU/lb. for the high temperature reservoir. Values should be considered approximate only, unless measured. "Measured" high temperature reservoir contributions are from spinner logs.
5. Enthalpies for Prati 1A, Prati 7, Prati 30 and Wildhorse 5 were not calculated because of mechanical conditions affecting flow.

3. Only those wellhead values where the well was full open should be used in the enthalpy program, if the contribution from the high temperature reservoir is to be calculated.

Results

Once down-hole enthalpy is calculated, estimates of the contribution of the high temperature reservoir to the total flow of any well can be calculated. This is possible because enthalpy values for the "typical" Geysers reservoir and high temperature reservoir are known.

Table IV presents the calculated enthalpies (see Appendix VII) for all GEOOC's wells except for those with mechanical difficulties judged to create problems in the enthalpy calculation (e.g. condensation or bridging). The wells producing only from the "typical" Geysers reservoir have calculated downhole enthalpies from 1212 BTU/lb. to 1252 BTU/lb. The enthalpy values measured by T-P-S logs range from 1231 and 1251 BTU/lb. for the "typical" Geysers reservoir. Consequently, 1240 BTU/lb. was chosen as a value representative of the "typical" Geysers reservoir. Using a high temperature reservoir steam enthalpy from T-P-S logs of 1320 BTU/lb., the flow contribution from the high temperature reservoir is estimated and also presented for each well on Table IV.

Comparison of the flow contribution estimates to the size and number of known steam entries in the high temperature reservoir, indicates that the estimates of Table IV are reasonable. For example, high temperature steam is estimated to make only a 3% contribution to the total flow of Prati 38. The lithology log for Prati 38 shows only one small (6 psi, $2^{o}F$) steam entry at 8603' in the high temperature zone so the 3% estimate is judged reasonable. Conversely, inspection of the steam entry sizes and locations given on the lithology log for Prati State 31 indicates about half of the major steam entries are from the high temperature zone; consequently, the estimated value of 56% based on enthalpy calculations is judged to be reasonable.

It must be emphasized that the calculated contributions of the steam from the high temperature reservoir are considered reasonable estimates only. Although inspection of the number and size of steam entries within the high temperature reservoir from the lithology logs indicate that the calculated estimates for contribution of the high temperature reservoir are reasonable, a mathematical evaluation of the variance between calculated and observed results is not available. Using the results from Table IV for estimated high temperature reservoir contributions, the H_2S concentration from this zone was also derived by calculating the mass balance of H_2S measured at the wellhead and subtracting the measured contributions from the "typical" reservoir. The estimated H_2S concentration in steam from the high temperature reservoir is presented in Appendix II: the range is estimated from 1000 to 3500 ppmw, or more.

Similarly, the results from Table IV were applied to the total flow rate of steam from each well in Area A-1, Area A-2 and Area-3. The total steam contribution of the high temperature reservoir to each power plant area is estimated as a percentage of the total steam and presented in Appendix III: less than 10% of the steam from Area A-1, approximately one-quarter from Area A-2, and almost one-half from Area-3 is from the high temperature reservoir.

Because the results in Appendices II and III are only as good as the flow rate contribution estimates from the enthalpy program, these results must be used with caution. They are presented to encourage further data collection directly from the high temperature reservoir and are not a substitute for actual data. The estimates indicate that the high temperature reservoir is important as a significant source of both steam and noncondensible gas to the CCPA Coldwater Creek Power Plant.

CONCEPTUAL MODEL

A model to explain the presence of the high temperature reservoir should incorporate the following facts:

1. There are no known significant lithologic or mineralogic differences that distinguish the high temperature and "typical" reservoirs from each other.
2. There is very little natural surface venting of hydrothermal fluids in the Northwest Geysers area.
3. The top of steam (-2500' to -4500' subsea) in the Northwest Geysers is deeper (1500'-2000') than most other production areas in The Geysers.
4. Noncondensible gas values are almost two orders of magnitude higher in the Northwest Geysers than the Southeast Geysers.
5. The source of water for the steam in the Southeast Geysers was originally meteoric, in the Northwest Geysers the source of water may include a connate component.
6. GEOOC wells in the "typical" reservoir of the Northwest Geysers are hydrologically connected to the main Geysers reservoir as demonstrated by declining static pressures.
7. The high temperature steam reservoir is under-pressured as is the "typical" reservoir.
8. There are no observable physical barriers between the high temperature and "typical" reservoir.

9. Temperature changes in a reservoir lag behind pressure changes.
10. Quaternary felsic intrusives are found in the subsurface throughout The Geysers.

The following theories for The Geysers should be considered in any model for the high temperature reservoir:

1. Isotope and mineralogical data indicate that a liquid-dominated, high temperature reservoir pre-dated the present "typical" vapor-dominated Geysers reservoir (Sternfeld, 1981).
2. The Geysers is not a single fracture reservoir but at least five discrete, overlapping convection cells controlled by fracturing (Thomas, 1981).

The high temperature steam reservoir in the Northwest Geysers is modeled here as a deep, evolving system in contrast to the shallower, leaky and mature steam reservoir(s) in the central and southeastern portions of the field. A recently drawn-down, unvented, and liquid-dominated system consisting of connate water may explain the high gas contents and unique isotopic composition relative to steam from a "typical" Geysers reservoir. The boundary therefore between the "typical" and high temperature reservoir is only a transient, thermodynamic condition due to the recent evolution of a vapor-dominated region from a liquid-dominated zone which has yet to cool down. Pressure in the two reservoirs is essentially the same because they are in communication with each other. In other words, the temperature change in the high temperature reservoir is lagging the pressure change.

<u>Evolution of The Geysers Reservoir</u>

Quaternary felsic intrusives, probably related to the Clearlake volcanics, intruded the Franciscan graywacke and associated rocks. The processes of intrusion caused heating, uplift, fracturing and faulting. Uplift in The Geysers initiated deep erosion and landsliding which gave The Geysers area a geomorphic signature that is different than the surrounding areas.

The process of intrusion resulted in extensive fracturing and thermal metamorphism of the graywacke in proximity to the intrusion. Conductive heating of the formation water in the fracture system around the intrusives started (a) hydrothermal system(s). This initial hydrothermal system is probably responsible for the deposition of Quaternary mercury deposits once mined at the periphery of The Geysers field and hornfels development. The hornfels grades from totally recrystallized graywacke near the intrusions, to graywacke having biotite-tourmaline minerals located proximal to fractures. The estimated minimum temperature of formation of a biotite-tourmaline hornfels is about 660°F exceeding current maximum temperatures in the "typical" Geysers reservoir, but not in the high temperature reservoir. The biotite-tourmaline hornfels is also found in wells penetrating only the "typical" reservoir.

Where the intrusive felsites were sufficiently close as in the Southeast Geysers, the associated fracture system propogated to the surface allowing venting of the hydrothermal system.

Venting of the hydrothermal system allowed decompression of the fluids which began a processes of boiling and convection. The large, surficially altered, areas in the Southeast and Central Geysers are a record of both past and present degassing of the system. Relatively little carbon dioxide (500± ppmw) and H_2S (50-100 ppmw) are presently found in the steam from wells <u>nearest</u> these vent areas.

It is presumed that near-surface fracturing consequent to intrusion not only allowed the venting of hydrothermal fluids, but also allowed the entry of meteoric water into the system(s). As the liquid-dominated hydrothermal system(s) boiled-down through the vent areas, an influx of meteoric water began dilution of the formation water (Truesdell and others, 1986).

The present steam reservoir found in the Southeast Geysers is believed to be from a completely boiled-down liquid system, extensively diluted by meteoric water that has lost most of its original gas and formation water. (Truesdell and others, 1986). The steam in these areas is shallow, with very low gas content and continues to vent as hot springs and fumaroles. Several deep wells in these areas bottom in felsite bodies.

The Northwest Geysers is believed to be following the same evolutionary development as in the Southeast and Central Geysers; however, the process is slower. The high temperature reservoir is the boiled-down remnant of the liquid-dominated reservoir. A "brine" or liquid-dominated system below the high temperature reservoir cannot be ruled out.

Evolution of the Northwest Geysers resevoir is believed to be slower because the felsic intrusions are deeper; only a few thin felsic dikes are encountered by wells and the hornfels development is very mild and deep (below -6000± subsea). The fracture system associated with the intrusive(s) therefore is also deeper, consequently, the top of steam is deeper than other parts of The Geysers where the felsite intrusives are known to be shallow. Venting of the deep Northwest Geysers system to the surface may therefore depend upon faults related to regional tectonism and interconnection with other fracture systems in the Central Geysers. The few vent areas in the Northwest Geysers are all associated with faults. Static pressure decline in unproduced GEOOC wells in the "typical" reservoir suggest connection with the fracture system(s) of wells now being produced in the Central Geysers. Not only is current Central Geysers production an artificial vent, it is reasonable to assume that the area of extensive alteration near Geysers Resort and along Big Sulphur Creek may also naturally vent the Northwest Geysers.

The consequences of a poorer surface connection with the steam reservoir than the Central and Southeastern Geysers areas includes less venting of non-condensible gas and less complete dilution by meteoric water. The high temperature reservoir underlying the "typical" reservoir is believed to be simply a fossil of the liquid-dominated system in which the onset of convection is recent, leaving an important conductive element in the transfer of heat from the evolving hydrothermal system.

Temperature gradients in the top of 2,000'-3,000' of the caprock above the Northwest Geysers are indicative of conductive heat transfer and range from 5 to 9^{o}F/100'. With estimated gradients in the high temperature reservoir also in this range, it is concluded that conduction remains an important mechanism for heat transfer in this reservoir.

This conceptual model differs in some respects from all published models for The Geysers field. Published models rely solely upon faulting to produce reservoir fracture systems and for lithologic changes and secondary mineralization to provide sealing. This model relies upon Quaternary felsic intrusives as the primary cause of reservoir fracturing. The depth of these felsic intrusions is thought to determine the top of steam, degree of sealing, and ultimately the evolution of the formation fluids which can presently be observed as vertically separated reservoirs.

MAW:bk
GE87-086.maw

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APPENDIX I - WELLBORE HEAT LOSS EQUATIONS

Nomenclature

α = earth diffusivity, sq.ft./hr.
a = geothermal gradient, $^{o}F/ft$
K = earth thermal conductivity, BTU/day ^{o}F ft
K_{cem} = cement thermal conductivity, BTU/day ^{o}F ft
Q = heat loss rate, BTU/day
r_i = inside radius of casing, ft
r_h = radius of hole, ft
r_o = outside radius of casing, ft
t = time from start of flow, days
T_e = temperature of earth at top of section, ^{o}F
T_s = temperature of steam at top of section, ^{o}F
U = overall heat transfer coefficient, BTU/day ft^2 ^{o}F
Z = depth change, ft

Heat loss for cased sections of well (Ramey, 1964)

$$Q = \frac{2 \pi r_i U K}{K + r_i U f(t)} [(T_s - T_e) Z - 0.5 a Z^2]$$

Heat loss for open hole sections of well (Ramey, 1964)

$$Q = \frac{2 \pi K}{f(t)} ((T_s - T_e) Z - 0.5 a Z^2)$$

Overall heat transfer coefficient (Willhite, 1967)

$$U = [r_o (\ln (r_h/r_o))/K_{cem}]^{-1}$$

Transient heat-conduction time function for radiation boundary condition model (Table 2 of Willhite, 1967)

where $\frac{\alpha t}{r_h^2}$	, then f(t)
<.1	0.313
0.1	0.445
0.2	0.588
0.5	0.811
1.0	1.02
2.0	1.25
5.0	1.59
10.0	1.88
20.0	2.17
50.0	2.58
100.0	2.90

Note: Values used for each well are listed in the section titled, "Enthalpy Calculations".

APPENDIX I - WELLBORE HEAT LOSS COMPUTER PROGRAM INPUTS

The enthalpy program usually calculates heat loss in increments of 200'. Increment values of 100', 500' and 1000' were also tested and found to provide useful results. An increment of 200' was selected because the greatest heat loss per foot occurs in the upper portions of a well where large diameter surface casing is often 200' to 300' in length. An increment of 100' was found to provide only an insignificant improvement in results compared to 200' but doubled the needed amount of computing time.

Typical data inputs for wells in the Northwest Geysers include a mean annual surface temperature of 60°F, graywacke thermal conductivity of 7.0 T.C.U. (40.62 BTU/ft.-day°F) and temperature gradients ranging from 5.8 to 8.6°F/100'. Other data inputs include the specific casing program for each well, specific wellhead data from flow tests, the depth to the first steam entry, rock diffusivity and cement thermal conductivity. Because graywacke is the predominant rock type, a diffusivity value of 1.2 ft^2/day was derived using a thermal conductivity of 7.0 T.C.U. (40.62 BTU/ft.-day-°F), a density of 2.67 gm/cm^3 (166.69 lb/cu. ft.), and an assumed specific heat of 0.20 BTU/lb-°F. Cement conductivity values were obtained from Halliburton for three cement slurries most commonly used at The Geysers:

- 1:1 Perlite : 10.32 BTU/day-ft-°F
- Tieback Slurry of G cement + 40% silica flour : 11.76 BTU/day-ft-°F
- Spherulite cement: 4.73 BTU/day-ft-°F

The thermal conductivity of G cement used for surface casing is not available; but because it is most like the tieback slurry, a value of 11.0 BTU/day-ft-°F is assumed for the computer program.

APPENDIX I

WELLBORE HEAT LOSS COMPUTER PROGRAM

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```
rem **********************************************************
rem *                                                        *
rem * Program name:   wbq.bas                                *
rem * Programmer  :   Mary Shileikis     Date: 03/27/87      *
rem * Language    :   CBASIC                                 *
rem *                                                        *
rem * Modifications :                    Date: 04/09/87      *
rem *                                          04/21/87      *
rem *                                                        *
rem * Function: This program accepts user input of well-    *
rem *           head measurements and casing lengths &       *
rem *           diameters and calculates the pressure        *
rem *           loss and heat loss for each section to       *
rem *           arrive at the pressure, enthalpy, and        *
rem *           temperature of the steam at the first        *
rem *           steam entry.                                 *
rem *           The program also has a print option.         *
rem *                                                        *
rem * Files    :        intp.wbq - data for time function    *
rem *                              table                     *
rem *           'wellname'.wbq - data file created from      *
rem *                              terminal input            *
rem *                                                        *
rem * I/O variables:                                         *
rem *     Terminal input:                                    *
rem *           well$      - well name                       *
rem *           yn$        - yes/no responses from terminal  *
rem *           a          - geothermal gradient,            *
rem *                        degrees F/ft                    *
rem *           K(I)       - earth thermal conductivity for  *
rem *                        i'th casing section, BTU/day    *
rem *                        degrees F                       *
rem *           alpha(I) - earth diffusivity for i'th        *
rem *                        casing section, sq.ft./day      *
rem *           t          - time from start of flow, days   *
rem *           Te         - temp of earth at top of section,*
rem *                        degrees F                       *
rem *           Ts         - temp of steam at top of section,*
rem *                        degrees F                       *
rem *           deltal     - depth change, ft (delta length) *
rem *           whp        - well head pressure, psia        *
rem *           w          - delivery, lbs/hr                *
rem *           totdepth - well depth, feet                  *
rem *           cL(I)      - length of i'th casing section,  *
rem *                        feet                            *
rem *           idia(I)    - inside diameter of i'th casing  *
rem *                        section, inches                 *
rem *           odia(I)    - outside diameter of i'th casing *
rem *                        section, inches                 *
rem *           hdia(I)    - hole diameter of i'th casing    *
rem *                        section, inches                 *
rem *           Kcem(I)    - cement thermal conductivity of  *
rem *                        i'th casing section, BTU/day    *
rem *                        degrees F/ft                    *
rem *                                                        *
rem **********************************************************
%eject
rem **********************************************************
rem *                                                        *
rem *     Input from data file:                              *
rem *           pra          - geothermal gradient,          *
rem *                          degrees F/ft                  *
```

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```
rem *          prt          - time from start of flow, days *
rem *          prTe         - temp of earth at top of       *
rem *                         section, degrees F            *
rem *          prTs         - temp of steam at top of       *
rem *                         section, degrees F            *
rem *          prdelta1     - depth change, ft (delta lngth)*
rem *          prwhp        - well head pressure, psia      *
rem *          prw          - delivery, lbs/hr              *
rem *          prtotdepth   - well depth, feet              *
rem *          prcL(I)      - length of i'th casing section,*
rem *                         feet                          *
rem *          pridia(I)    - inside diameter of i'th       *
rem *                         casing section, inches        *
rem *          prodia(I)    - outside diameter of i'th      *
rem *                         casing section, inches        *
rem *          prhdia(I)    - hole diameter of i'th casing  *
rem *                         section, inches               *
rem *          prK(I)       - earth thermal conductivity of *
rem *                         i'th casing section, BTU/day  *
rem *                         degrees F                     *
rem *          pralpha(I)   - earth diffusivity of i'th     *
rem *                         casing section, sq.ft./day    *
rem *          prKcem(I)    - cement thermal conductivity   *
rem *                         of i'th casing section,       *
rem *                         BTU/day degrees F/ft          *
rem *     Output variables:                                 *
rem *          pr(I)        - pressure at bottom of i'th    *
rem *                         casing section                *
rem *          en(I)        - enthalpy at bottom of i'th    *
rem *                         casing section                *
rem *          bt(I)        - temperature at bottom of i'th *
rem *                         casing section                *
rem *     Calculated values:                                *
rem *          H            - enthalpy at top of section    *
rem *          prh          - initial value of enthalpy     *
rem *          ph           - enthalpy plus delta heat      *
rem *          ENTH         - enthalpy at bottom of section *
rem *          TEMP         - steam temperature             *
rem *          ETEMP        - earth temperature             *
rem *          PRESS        - pressure                      *
rem *          Z            - delta length                  *
rem *          length       - casing length                 *
rem *          deltapr      - change in pressure            *
rem *          V            - specific volume of super-     *
rem *                         heated steam                  *
rem *          Q            - heat loss                     *
rem *          U            - heat transfer coefficient     *
rem *          F            - transient heat conduction     *
rem *                         value                         *
rem *                                                       *
rem *********************************************************
%eject
rem *********************************************************
rem *                                                       *
rem *     Constants:                                        *
rem *               pi   = 3.141592654                      *
rem *               c1   = 2.1082E-07                       *
rem *          FT(I,J)   = 2-dimensional array value from   *
rem *                      time function table used to      *
rem *                      calculate F                      *
rem *     Other variables:                                  *
rem *          fname$     - file to write data to           *
```

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```
rem *          depth        - total depth of casing          *
rem *                         sections                       *
rem *          pra          - previous geothermal gradient   *
rem *          prK(I)       - previous earth thermal         *
rem *                         conductivity of i'th casing    *
rem *                         section                        *
rem *          pralpha(I) - previous earth diffusivity of    *
rem *                         i'th casing section            *
rem *          prt          - previous time from start of    *
rem *                         flow                           *
rem *          prTe         - previous temp of earth at top  *
rem *                         of section                     *
rem *          prTs         - previous temp of steam at top  *
rem *                         of section                     *
rem *          prdeltal     - previous delta length          *
rem *          prwhp        - previous sell head pressure    *
rem *          prw          - previous delivery              *
rem *          prtotdepth - previous well depth              *
rem *          prcL(I)      - previous length of i'th        *
rem *                         casing section, feet           *
rem *          pridia(I)    - previous inside diameter of    *
rem *                         i'th casing section, inches    *
rem *          prodia(I)    - previous outside diameter of   *
rem *                         i'th casing section, inches    *
rem *          prhdia(I)    - previous hole diameter of      *
rem *                         i'th casing section, inches    *
rem *          prKcem(I)    - previous cement thermal con-   *
rem *                         ductivity of i'th casing       *
rem *                         section, BTU/day degrees F/ft  *
rem *      Flags:                                            *
rem *          ans$       - write data to file flag          *
rem *          cemon$     - cement thermal conductivity      *
rem *                       prompt flag                      *
rem *          c1true     - accept casing input flag         *
rem *          errflag$ - data file not found flag           *
rem *          error$     - error flag                       *
rem *          file$      - read data from file flag         *
rem *          first      - first time entries have been     *
rem *                       made flag                        *
rem *          prton      - print results flag               *
rem *          prntr      - printing in progress flag        *
rem *          yval$      - y value found flag               *
rem *                                                        *
rem ******************************************************
%eject
rem ******************************************************
rem *                                                        *
rem * Formulae used:                                         *
rem *                                                        *
rem *      Conversion of inside casing, outside casing, &    *
rem *      hole diameters from inches to feet:               *
rem *                                                        *
rem *         ri = (idia(I)/12) / 2                          *
rem *         ro = (odia(I)/12) / 2                          *
rem *         rh = (hdia(I)/12) / 2                          *
rem *                                                        *
rem *      Y value used in time function table:              *
rem *                                                        *
rem *         Y = (alpha(I)*t)/(rh^2)                        *
rem *                                                        *
rem *      Fritzche's formula:                               *
rem *                                                        *
```

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```
rem *                    2.1082 * v * Z * w^1.85               *
rem *        deltapr = -----------------------                 *
rem *                         d^4.97 * 10^7                    *
rem *                                                          *
rem *        where                                             *
rem *                                                          *
rem *           deltapr = delta change in pressure             *
rem *                 v = specific volume of superheated       *
rem *                     vapor                                *
rem *                 d = internal diameter of casing in       *
rem *                     inches                               *
rem *                                                          *
rem *     Heat loss equations:                                 *
rem *                                                          *
rem *        Transient heat-conduction time function for       *
rem *        earth:                                            *
rem *                                                          *
rem *          f(t) = ln (2*sqr(0.96*t)/rh) - 0.29             *
rem *                                                          *
rem *        Overall heat transfer coefficient:                *
rem *                                                          *
rem *          U = 1/(ro*(ln (rh/ro))/Kcem(I))                 *
rem *                                                          *
rem *        Heat loss for open hole sections of well:         *
rem *                                                          *
rem *        Q = ((2*pi*K(I))/f(t))*((Ts-Te)*Z-0.5*a*Z^2)      *
rem *                                                          *
rem *        Heat loss for cased sections of well:             *
rem *                                                          *
rem *          Q = ((2*pi*ri*U*K(I))/(K(I)+ri*U*f(t))          *
rem *                *((Ts-Te)*Z-0.5*a*Z^2)                    *
rem *                                                          *
    ********************************************************
eject

    DIM idia(10),odia(10),hdia(10),cL(10),pr(10),en(10),bt(10)
    DIM Kcem(10),FT(11,15),prcL(10),pridia(10),prodia(10)
    DIM prhdia(10),prKcem(10),K(10),alpha(10),prK(10),pralpha(10)
    pi=3.141592654
    first=1
    prntr=0
    well$=" "
    c1=2.1082E-07
    A$ = "        #         ####.#####     ####.#####      ####.#####"
    B$ = "         Enthalpy at Wellhead ####.#### BTU\/lbm"
    ERRFLAG$="ON"
    IF END #3 THEN 5
    OPEN "INTP.wbq" AS 3
    ERRFLAG$="OFF"
rem * load time function values into table
    FOR L = 0 TO 10
    FOR M = 0 TO 14
       READ #3;FT(L,M)
    NEXT M
    NEXT L
rem * if data file containing table values not found, stop
5   IF ERRFLAG$="ON" THEN PRINT " DATA FILE NOT FOUND??":stop
    CLOSE 3

rem * clear screen
10  error$="false"
    print chr$(12)
```

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```
     print well$; " Wellbore Heat Loss Calculation "
     print
     print "Press RETURN to assume previous name":print
     file$="off"
     input "Well Name (8 char. max.) ? "; line yn$
     if yn$ > " " then  well$=yn$
     input "Read data from file (y/n) ?";yn$
     if UCASE$(yn$)="Y" then file$="on"
 rem * if user answers yes, read values from well file
     fname$=" "
     LPRINTER:print "Well Name ";well$:CONSOLE
     while file$="on"
        fname$ = well$ + ".wbq"
        if end #1 then 15
        open fname$ as 1
        read #1;pra
        read #1;prt
        read #1;prte
        read #1;prts
        read #1;prdeltal
        read #1;prwhp
        read #1;prw
        read #1;prtotdepth
 %eject
        for I = 1 to 10
           read #1;prcL(I)
           read #1;pridia(I)
           read #1;prodia(I)
           read #1;prhdia(I)
           read #1;prK(I)
           read #1;pralpha(I)
           cL(I)=prcL(I):idia(I)=pridia(I):odia(I)=prodia(I)
           K(I)=prK(I):alpha(I)=pralpha(I)
           hdia(I)=prhdia(I)*2
           if pridia(I) <> 0 then\
              read #1;prKcem(I):\
              Kcem(I)=prKcem(I)\
           else I = 11
        next I
        close 1
        file$="off"
    wend
rem * if well file not found, print error message
rem * user may enter new well name or stop
15  if file$="on" then\
        print "Data file not found ??":\
        input "Try another well name (y/n) ?";yn$:\
        if UCASE$(yn$)="Y" then goto 10 else goto 90

rem * get user option to print results
    input "Do you want a printed output (y/n)";yn$
    if UCASE$(yn$)="Y" then prton=1\
    else prton=0
    print
rem * accept input data from terminal
    print "Hit RETURN to assume previous value":print
    print using "Geothermal gradient, degrees F/ft       ####.###"\
       ;pra;
    input line yn$
    if yn$="" then a=pra\
    else a=VAL(yn$)
    pra=a
```

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```
     print using "Time from start of flow, Hours           ####.## "\
        ;prt;
     input line yn$
     if yn$="" then t=prt/24\
     else t=VAL(yn$):prt=t:t=t/24.0
     print using "Temp. of earth at Well Head, degrees F ####.## "\
        ;prTe;
     input line yn$
     if yn$="" then Te=prTe\
     else Te=VAL(yn$)
     prTe=Te
 %eject
     print using "Temp. of steam at Well Head, degress F ####.## "\
        ;prTs;
     input line yn$
     if yn$="" then Ts=prTs\
     else Ts=VAL(yn$)
     prTs=Ts
     print using "Depth change, ft (delta length)         ####    "\
        ;prdeltal;
     input line yn$
     if yn$="" then deltal=prdeltal\
     else deltal=VAL(yn$)
     prdeltal=deltal
     print using "Well head pressure, psia                ####.## "\
        ;prwhp;
     input line yn$
     if yn$="" then whp=prwhp\
     else whp= VAL(yn$)
     prwhp=whp
     print using "Delivery, lbs/hr                      ######.   "\
        ;prw;
     input line yn$
     if yn$="" then w=prw\
     else w=VAL(yn$)
     prw=w
     input "Are input data OK ? (y/n) ";yn$
     if UCASE$(yn$)="N" then goto 10
 25  print using "Depth of first steam entry              ####.## "\
        ;prtotdepth;
     input line yn$
     if yn$="" then totdepth=prtotdepth\
     else totdepth=VAL(yn$):depth=totdepth
     prtotdepth=totdepth
     if first then first=0 : goto 30
rem * if not the first time ask if same casings to be used in
rem * calculation again
rem print " Enter Values - <RETURN> does NOT assume previous values"
     input " Do you want to use same casing program ? (y/n)       "\
        ;yn$
     if UCASE$(yn$)="Y" then goto 50
30   print "Enter 0 (zero) for casing length to QUIT"
     depth=0
rem * get dia. casing lengths till user enters 0 for length
     for I = 1 to 10
rem * prompt for cement thermal conductivity after each set of
rem * casing section entries unless entries are for open hole
rem * section
%eject
        if (I > 1) and (idia(I-1) > 0) then cemon$="true"\
        else cemon$="false"
        if cemon$="true" then\
```

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```
            print using " Cement thermal cond (BTU/day) ###.### "\
               ;prKcem(I-1);:\
            input line yn$:\
            if yn$="" then Kcem(I-1)=prKcem(I-1) else Kcem(I-1)=VAL(yn$):\
            prKcem(I-1)=Kcem(I-1):\
            cemon$="false"
         print using " Casing \## length    (feet)    ####.####"\
            ;I,prcL(I);
         input line yn$
         if yn$="" then cL(I)=prcL(I) else cl(I)=VAL(yn$)
         prcL(I)=cL(I)
         if cl(I) > 0 then cltrue=1 else cltrue=0: I=11
         while cltrue
            depth=depth+cL(I)
            print using " Inside    diameter  (inches) ####.####"\
               ;pridia(I);
            input line yn$
            if yn$="" then idia(I)=pridia(I)\
            else idia(I)=VAL(yn$): pridia(I)=idia(I)
            print using " Outside   diameter  (inches) ####.####"\
               ;prodia(I);
            input line yn$
            if yn$="" then odia(I)=prodia(I)\
            else odia(I)=VAL(yn$): prodia(I)=odia(I)
            print using " Hole      radius    (inches) ####.####"\
               ;prhdia(I);
            input line yn$
            if yn$="" then hdia(I)=prhdia(I)*2\
            else prhdia(I)=VAL(yn$):hdia(I)=prhdia(I)*2
            print using " Earth thermal cond. (TCU)    ####.##  "\
               ;prK(I);
            input line yn$
            if yn$="" then K(I)=prK(I)*5.8033 else K(I)=VAL(yn$):\
            prK(I)=K(I):K(I)=K(I)*5.8033
            print using " Earth diff (alpha-sq.ft/day) ####.##  "\
               ;pralpha(I);
            input line yn$
            if yn$="" then alpha(I)=pralpha(I) else alpha(I)=VAL(yn$):\
            pralpha(I)=alpha(I)
            cltrue=0
         wend
    next I
rem * check if length of casings entered = total depth of well
50  if depth<>totdepth then print chr$(7):print:\
       print "** Depth of first steam entry not equal to total ";:\
       print "casing length ** ":goto 25
    print
    input "Are casing program input data OK ? (y/n) ";yn$
    if UCASE$(yn$)="N" then goto 25
60  print
    print "***** Please wait - calculating results *****":print
    gosub 100
%eject
rem * if no errors found, output results
    if error$="false" then gosub 300
    print
    input " Save values in file (y/n) ?";yn$
    ans$=UCASE$(yn$)
    * if answer = yes, write well data to file
80  while ans$="Y"
       fname$=""
       input " Enter well name (8 char. max.) ";line fname$
```

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```
        if fname$<=" " then fname$=weil$
        fname$ = fname$ + ".wbq"
        create fname$ as 1
        print #1;pra,prt,prte,prts,prdelta1,prwhp,\
           prw,prtotdepth:\
        for I = 1 to 10
            print #1;prcL(I),pridia(I),prodia(I),prhdia(I),prK(I),pralpha(I)
            if pridia(I) <> 0 then print #1;prKcem(I) else I = 11
        next I
        close 1
 82     ans$="N"
     wend
 85  print
 rem * ask if user wants to run program again
     input " Continue (y/n) ";yn$
     if UCASE$(yn$)<>"N" then goto 10
 90  STOP
 100 rem * calculate pressure, enthalpy, and temperature for
     rem * each casing section & first steam entry
     TEMP = Ts
     ETEMP = Te
     PRESS = whp
 rem * if steam temp < earth temp, set error flag & exit
 rem * calculation routine
     if TEMP < ETEMP then\
        print "Temp. of steam less than temp. of earth":\
        print "Calculations aborted":error$="true":goto 200
     I=1
 rem * calculate initial enthalpy
     gosub 60610
     ph = H:prH = H
     print using B$;ph
     * perform calculations until casing length equals zero
     while cL(I) > 0
        Z = delta1
        length = cL(I)
        ri = (idia(I) / 12) / 2
        ro = (odia(I) / 12) / 2
        rh = (hdia(I) / 12) / 2
        if idia(I) = 0 then d = hdia(I)\
        else d = idia(I)
        if idia(I) > 0 then\
           U = 1/(ro * (log (rh/ro)) / Kcem(I))\
        else U = 0.0
%eject
rem * calculate transient heat conduction
        gosub 1000
        print using "        f = ####.#### U = ####.####";f,U
rem * calculate temperature, pressure, & enthalpy for
rem * i'th casing section
      while length <> 0
         if length < Z then Z = length
rem * calculate specific volume of superheated steam
         gosub 62590
         deltapr = (c1 * v * Z * (w^1.85)) / (d^4.97)
         if idia(I) > 0 then\
            Q = ((pi*ri*U*K(I)*2.0)/(K(I)+ri*U*f))*((TEMP-ETEMP)*Z-a*(Z^2.0)*0.5))\
         else Q = ((pi*K(I)*2.0)/f)*((TEMP-ETEMP)*Z-a*(Z^2.0)*0.5)
         Q = Q/(w*24)
rem * print results for each casing segment
         LPRINTER
         print using " Z = ####. ";Z;
```

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```
        print using " F(t) = ####.## ";F;
        print using " U = ####.## ";U;
        print using " Q = ####.## ";Q;
        print using " Ts = ####.## ";TEMP;
        print using " Te = ####.##";ETEMP
        CONSOLE
   * calculate cumulative pressure, enthalpy, & earth temp for
   * full well depth
        PRESS  = PRESS + DELTAPR
        ETEMP  = ETEMP + a * Z
        ph     = ph + Q
        ENTH   = ph
        print using "      Q = ####.#### H = #####.####";Q,ph
        length = length - Z
rem * calculate temperature of superheated steam
        gosub 62130
rem * if error flag set, exit routine
        if error$="true" then goto 200
        TEMP=ST
      wend
rem * save pressure, enthalpy, & temp for each casing section
      PR(I)=PRESS
      EN(I)=ENTH
      BT(I)=ST
      I = I + 1
rem LPRINTER
rem print using "f = ####.#### Q = ####.#### U = ####.####";f,Q,U
rem CONSOLE
    wend
200 RETURN
%eject
300 rem * output user input & results
    print "                          ";well$;" Wellbore Heat Loss"
    print:print "                          **** INPUT DATA ****"
    print
    print " Geothermal Gradient              = ";a;  " degrees F/ft"
    print " Time From Start of Flow          = ";prt;" hrs"
    print " Earth Temp. at Well Head         = ";Te; " degrees F"
    print " Steam Temp. at Well Head         = ";Ts; " degrees F"
    print " Depth change (delta length)      = ";deltal;" feet"
    print " Well Head Pressure               = ";whp;" psia"
    print " Steam Delivery                   = ";w;" lbs/hr"
    if prntr=0 then input " Hit any key to continue ";line yn$
    print
    print " Depth of First Steam Entry       = ";totdepth;" feet"
    I=1
    while cL(I) > 0
       print:print " Casing #";I
       print " Casing  length   (feet)     = ";cL(I)
       print " Inside  diameter (inches)  = ";idia(I)
       print " Outside diameter (inches)  = ";odia(I)
       print " Hole    radius   (inches)  = ";hdia(I)/2
       print " Earth Thermal Conductivity = ";prK(I);" TCU"
       print " Earth Diffusivity (alpha)  = ";alpha(I);" sq.ft./day"
       if idia(I) > 0 then\
       print " Cement thermal cond.       = ";Kcem(I);\
          " BTU/day degrees F/ft"
       I = I + 1
    wend
    if prntr=0 then input " Hit any key to continue ";line yn$
    if prntr then print chr$(12)
    print
```

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```
    print "                    **** ";well$;" RESULTS ****"
    print
    print " NOTE: First Steam Entry is Bottom of Last Casing"
    print:print using B$;prH
    print
    print "  Casing #       Pressure       Enthalpy       Temperature"
    print "                  (psia)        (BTU/lbm)        (deg. F)"
    print "  --------       --------       --------       -----------"
    print
    I = 1
    J = I + 1
    while cL(J) <> 0
       print using A$;I;PR(I);EN(I);BT(I)
       I = I + 1
       J = I + 1
    wend
    print using A$;I;PR(I);EN(I);BT(I)
%eject
rem * output input & results to printer
rem * if printer output selected
    if prntr then print chr$(12)
    if prton then\
       print:print " Printing results - please wait":\
       prton=0:prntr=1:LPRINTER:goto 300
    CONSOLE
    prntr=0
    RETURN
1000 rem * calculate transient heat conduction
     rem * set flags to indicate X & Y values have not been
     rem * found in table
     XVAL$="FALSE":YVAL$="FALSE"
     M=14
     REM IF U>0 THEN X=(ri*U)/K(I)
     REM IF X > 100 THEN M = 13:GOTO 1020
     REM L=0:M=1
     REM WHILE XVAL$="FALSE"
     REM     IF FT(L,M) < X THEN M=M+1
     REM     IF FT(L,M) = X THEN XVAL$="TRUE"
     REM     IF FT(L,M) > X THEN XVAL$="TRUE":M=M-1
     REM WEND
1020 Y=(alpha(I)*t)/(rh^2)
     IF Y < 0.1 THEN F = 0.313:RETURN
     IF Y > 100 THEN L = 10:GOTO 1030
     L=1:N=0
rem * search for Y value in table
     WHILE YVAL$="FALSE"
        IF FT(L,N) < Y THEN L=L+1
        IF FT(L,N) = Y THEN YVAL$="TRUE"
        IF FT(L,N) > Y THEN YVAL$="TRUE":L=L-1
     WEND
1030 REM IF M <> 14 THEN\
     REM     TEMP1 = ((X-FT(0,M))*(FT(L,M+1)-FT(L,M)))^2:\
     REM     TEMP2 = (FT(0,M+1)-FT(0,M))^2:\
     REM     CALC1 = TEMP1/TEMP2\
     REM ELSE CALC1=0
     CALC1=0
     IF L <> 10 THEN\
        TEMP1 = ((Y-FT(L,0))*(FT(L+1,M)-FT(L,M)))^2:\
        TEMP2 = (FT(L+1,0)-FT(L,0))^2:\
        CALC2 = TEMP1/TEMP2:\
        C = SQR(CALC1+CALC2)\
     ELSE IF M <> 14 THEN C = SQR(CALC1)
```

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```
      IF (M = 14) AND (L = 10) THEN\
         F = FT(L,M)\
      ELSE F = FT(L,M) + (FT(L,M)*C)
 RETURN
 %eject
 60610 REM ENTHALPY OF SUPERHEATED STEAM AS A FUNCTION OF
 60611 REM TEMERATURE AND PRESSURE
 60620 Z67=TEMP:Z52=PRESS
 60630 Z66=255.38+Z67/1.8
 60640 IF Z88=1 THEN Z66=255.38+(Z67-459.69)/1.8
 60650 IF Z66<=0 THEN Z66=9.999999E-06
 60660 Z51=Z52/14.6959
 60670 Z12=(2641.62*10.0^(80870/(Z66*Z66)))/Z66
 60680 Z11=1.89-Z12:Z13=82.54601
 60690 Z14=162460/Z66:Z15=.21828*Z66
 60700 Z16=126970/Z66
 60710 Z39=1.89-Z12*(372420/(Z66*Z66)+2)
 60720 Z17=Z11*Z14-2*Z39*(Z13-Z14)
 60730 Z18=2*Z39*(Z15-Z16)-Z11*Z16
 60740 Z19=.4342944*LOG(Z66)
 60750 Z38=775.596+(.63296+.0001624*Z66)*Z66+47.3635*Z19
 60760 Z20=Z11*Z51*Z51/(2*Z66*Z66)
 60770 H=Z38+.043577*(Z39*Z51+Z20*(Z11*(Z13-Z14+2*Z18*Z20)-Z17))
 60780 RETURN

 62130 REM TEMPERATURE OF SUPERHEATED STEAM-H,P
 62140 Z52=PRESS:Z43=ENTH
 62150 Z50=0:Z36=0
 62160 Z35=.01
 62170 Z32=2
 62180 Z86=1.68*Z43-1110
 62190 Z67=Z86
 62200 Z88=1
 62210 GOSUB 60630
 62220 Z41=H
 62230 FOR Z44=1 TO 10
 62240 Z75=Z86+Z32
 62250 Z67=Z75
 62260 GOSUB 60630
 62270 Z86=Z86+Z32*(Z43-Z41)/(H-Z41)
 62280 Z67=Z86
 62290 GOSUB 60630
 62300 Z41=H
 62310 IF ABS(Z43-Z41)-Z35<=0 then GOTO 62350
 62320 NEXT Z44
 62330 PRINT "RESULTS:"
 62340 PRINT "This function did not converge.";
       PRINT "  Check inputs of PRESS and ENTH":Z50=1:\
       error$="true":GOTO 62355
 62350 ST=Z86-459.69
 62355 Z88=0
 62360 RETURN
 %eject
 62590 REM SPECIFIC VOL. OF SUPERHEATED STEAM-T,P
 62600 Z67=TEMP:Z52=PRESS
 62610 Z66=(Z67-32)*5/9+273.16
 62620 Z51=Z52*6894.75729
 62630 Z21 = Z51/22120000:Z78=Z66/647.3
 62640 Z37=.7633333333*(1-Z78)
 62650 Z86=2.7182818^Z37
 62660 Z59=461.51:Z83=.00317
 62670 Z2=(Z59*Z66)/(Z51*Z83)
```

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```
62680 Z12=.06670375918*Z86^13 + 1.388983801*Z86^3
62690 Z13=(2*Z21*(.08390104328*Z86^18 + .02614670893*Z86^2 -.03373439453*Z86))
62700 Z14=(3*Z21^2*(.4520918904*Z86^18 + .1069036614*Z86^10))
62710 Z15=(4*Z21^3*(-.5975336707*Z86^25 - .08847535804*Z86^14))
62720 Z16=(5*Z21^4*(.5958051609*Z86^32 - .5159303373*Z86^28 +\
      .2075021122*Z86^24))
62730 Z9=Z12+Z13+Z14+Z15+Z16
62740 Z24=(4*Z21^(-5)*(.1190610271*Z86^12 - .09867174132*Z86^11))/\
      ((Z21^(-4) + .4006073948*Z86^14)^2)
62750 Z25=(5*Z21^(-6)*(.1683998803*Z86^24 - .05809438001*Z86^18)) /\
      ((Z21^(-5) + .08636081627*Z86^19)^2)
62760 Z26=(6*Z21^(-7)*(.006552390126*Z86^24 + .0005710218649*Z86^14)) /\
      ((Z21^(-6) -.8532322921*Z86^54 + .3460208861*Z86^27)^2)
62770 Z23=Z24+Z25+Z26
62780 Z22=15.74373327 - 34.17061978*Z78 + 19.31380707*Z78^2
62790 Z30=11*(Z21/Z22)^10*(193.6587558 - 1388.522425*Z86 + 4126.607219\
      *Z86^2 - 6508.211677*Z86^3 + 5745.984054*Z86^4 - 2693.088365\
      *Z86^5 + 523.5718623*Z86^6)
62800 V=Z83*(Z2-Z9-Z23+Z30)*16.0184634
62810 RETURN
```

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APPENDIX II

CALCULATED H_2S CONCENTRATION OF HIGH TEMPERATURE RESERVOIR STEAM

Well	"A" H_2S Concentration of "Typical" Reservoir Section [1]	"B" High Temperature Reservoir Contribution to Total Steam Flow of Well [2]	"C" H_2S Concentration of Total Steam Flow [3]	"D" Calculated H_2S Concentration of High Temperature Steam Reservoir [4]
Prati 5	N/A	48%	1000 ppmw	---
Prati 8	500 ppmw	26%	873 ppmw	1934 ppmw
Prati 9	450 ppmw	19%	1036 ppmw	3534 ppmw
Prati 25	700 ppmw	15%	1043 ppmw	2986 ppmw
Prati 30	450 ppmw	8%	1665 ppmw	15,638 ppmw
PS-31	500 ppmw	56%	2010 ppmw	3196 ppmw
Prati 32	700 ppmw	64%	1841 ppmw	2482 ppmw
Prati 37	700 ppmw	56%	1466 ppmw	2067 ppmw
Prati 38	700 ppmw	3%	753 ppmw	2466 ppmw
Prati 39	500 ppmw	50%	946 ppmw	1392 ppmw
Prati 50	500 ppmw	69%	848 ppmw	1004 ppmw

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Notes:

1. Concentrations interpreted from plots of Exlog-Smith H_2S trip gas data versus depth.
2. Concentrations from Table IV of this report.
3. Concentrations from Table III of this report.
4. Calculated H_2S concentration for high temperature reservoir: $D = \frac{C-(A*(1-B))}{B}$

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APPENDIX III

Estimated Contribution of High Temperature Steam Reservoir by Power Plant Area

Well	Total Flow Rate at 125 psig	Calculated/Measured* % Steam from High Temperature Reservoir	Estimated Flow Rate from High Temperature Reservoir
Power Plant Area A-1			
Prati 1A	Abandoned		
Prati State 1	121,100 lb/hr	None	
Prati 2	57,800	None	
Prati 4	206,000	None	
Prati 5	118,600	48%	53,400 lb/hr
Prati State 10	157,100	None	
Prati State 24	158,000	None	
Prati State 54	82,200	None	
Wildhorse 5	Injector		
Area Total:	900,800 lb/hr	6% (weighted average)	53,400 lb/hr
Power Plant Area A-2			
Prati 8	Injector		
Prati 9	Injector		
Prati 25	213,000 lb/hr	15%	31,950 lb/hr
Prati 27	204,300	None	
Prati 37	179,000	56%	100,240
Prati 38	204,600	3%	6,140
Prati 39	161,200	50%*	80,600
Prati 50	145,200	66%	95,830
Wildhorse 1	Abandoned		
Area Total:	1,107,300 lb/hr	28% (weighted average)	314,760 lb/hr
Area 3			
Prati 7	Abandoned		
Prati 30	*117,000 lb/hr	8%*	9,400 lb/hr
Prati State 31	*146,300	56%	81,900
Prati 32	*187,700	64%	120,100
Area Total:	451,000 lb/hr	47% (weighted average)	211,400 lb/hr

*Normalized values are not available.

APPENDIX IV
Thermal Conductivity Measurements of Hornfelsic Graywacke

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The graywacke of the high temperature reservoir is, in part, altered to a biotite-tourmaline hornfels. Because thermal conductivity values of hornfelsic graywacke from The Geysers were previously unavailable, it was decided to determine if the thermal conductivity of hornfelsic graywacke played a role in the presence of the high temperature reservoir.

The thermal conductivity of hornfelsic graywacke from four GEOOC wells was measured. Nineteen hornfels were selected for measurement. Each sample consisted of a composite of drill cuttings from a 100' interval. The thermal conductivity measurements were made by Geotech Data using aggregate cells.

The results are presented below with the same statistical measures for graywacke from which the hornfels is derived:

Statistical Measure	Hornfelsic Graywacke	Graywacke
No. of Samples:	19	187
Range of Values:	6.1 to 7.6 T.C.U.	5.6 to 9.3 T.C.U.
Median Value:	6.8 T.C.U.	7.5 T.C.U.
Arithmetic Mean ($\bar{\bar{x}}$) value:	6.8 T.C.U.	7.5 T.C.U.
Modal Value:	6.8 T.C.U.	7.4 T.C.U.

The range of thermal conductivity values of the hornfelsic graywacke falls in the same range as graywacke although it appears that a typical hornfelsic graywacke value is slightly lower than the typical graywacke value.

Depth Interval Feet	Assumed Porosity (%)	Thermal Conductivity (TCU)*
	Prati 37	
8400 - 8500	5	6.8
8500 - 8600	5	6.3
	Prati State 31	
8200 - 8300	5	6.6
8300 - 8400	5	7.0
8460 - 8490	5	7.5
8500 - 8600	5	6.8
8600 - 8680	5	7.6
8700 - 8780	5	7.6
8800 - 8900	5	6.6

Depth Interval Feet	Assumed Porosity (%)	Thermal Conductivity (TCU)*
	Prati 8	
8300 - 8400	5	6.5
8400 - 8500	5	7.3
	Rorabaugh 27	
9200 - 9300	5	6.1
9500 - 9600	5	7.1
9600 - 9700	5	6.8
9700 - 9800	5	6.8
9800 - 9900	5	6.9
9900 - 10000	5	6.8
10000 - 10100	5	6.5
10100 - 10200	5	6.2

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* 1 TCU = 1 mcal/cm-sec-deg C

APPENDIX V

TEMPERATURE-DEPTH PLOTS FOR GEOOC WELLS IN AREAS A-1, A-2, 3

Notes:

1. The maximum range of thermometers available to GEOOC when Prati 8 and Prati 9 were drilled was 500^{o}F.
2. 600^{o}F was the maximum temperature range of thermometers when Prati 7 was drilled.

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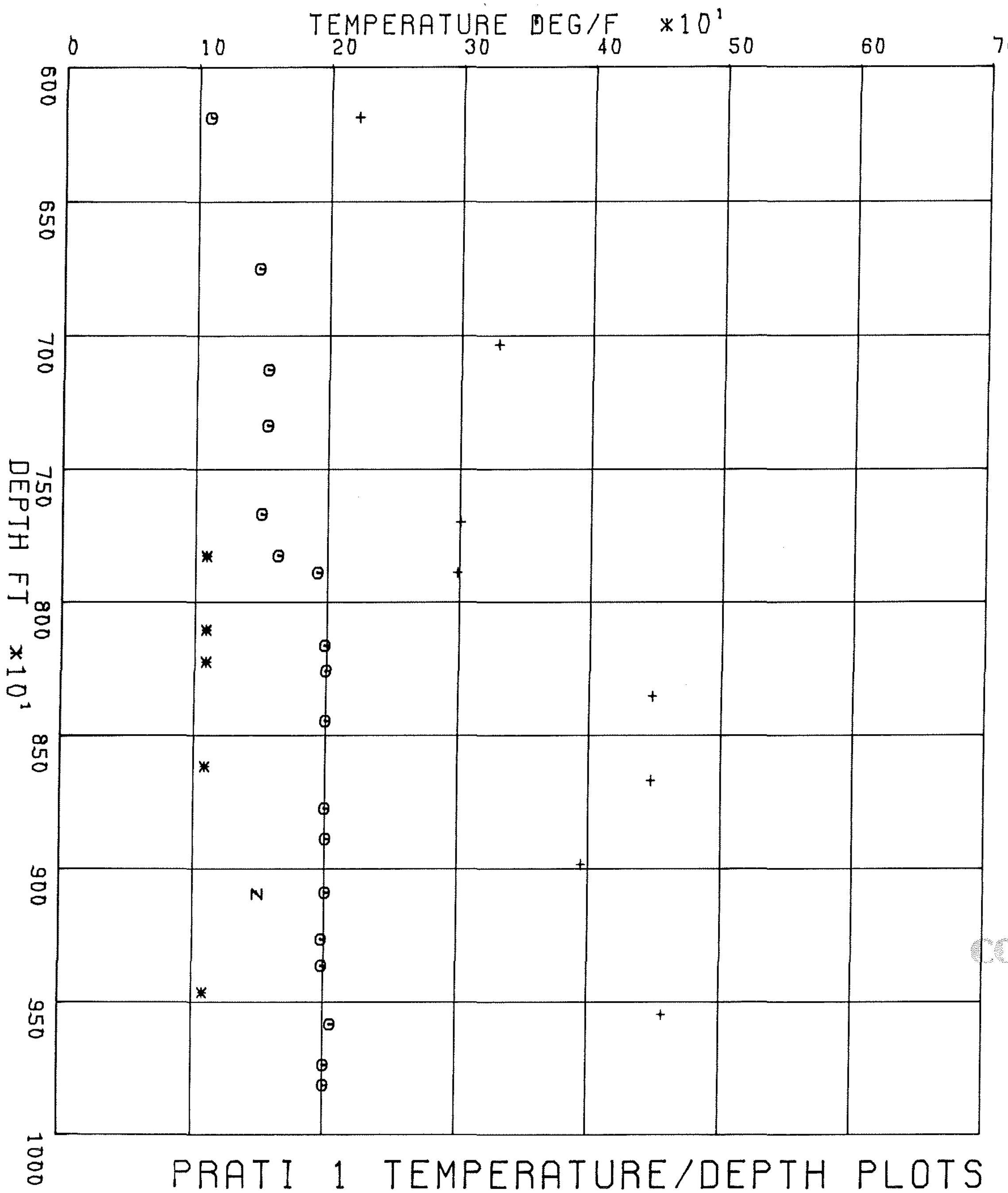

PRATI 1 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

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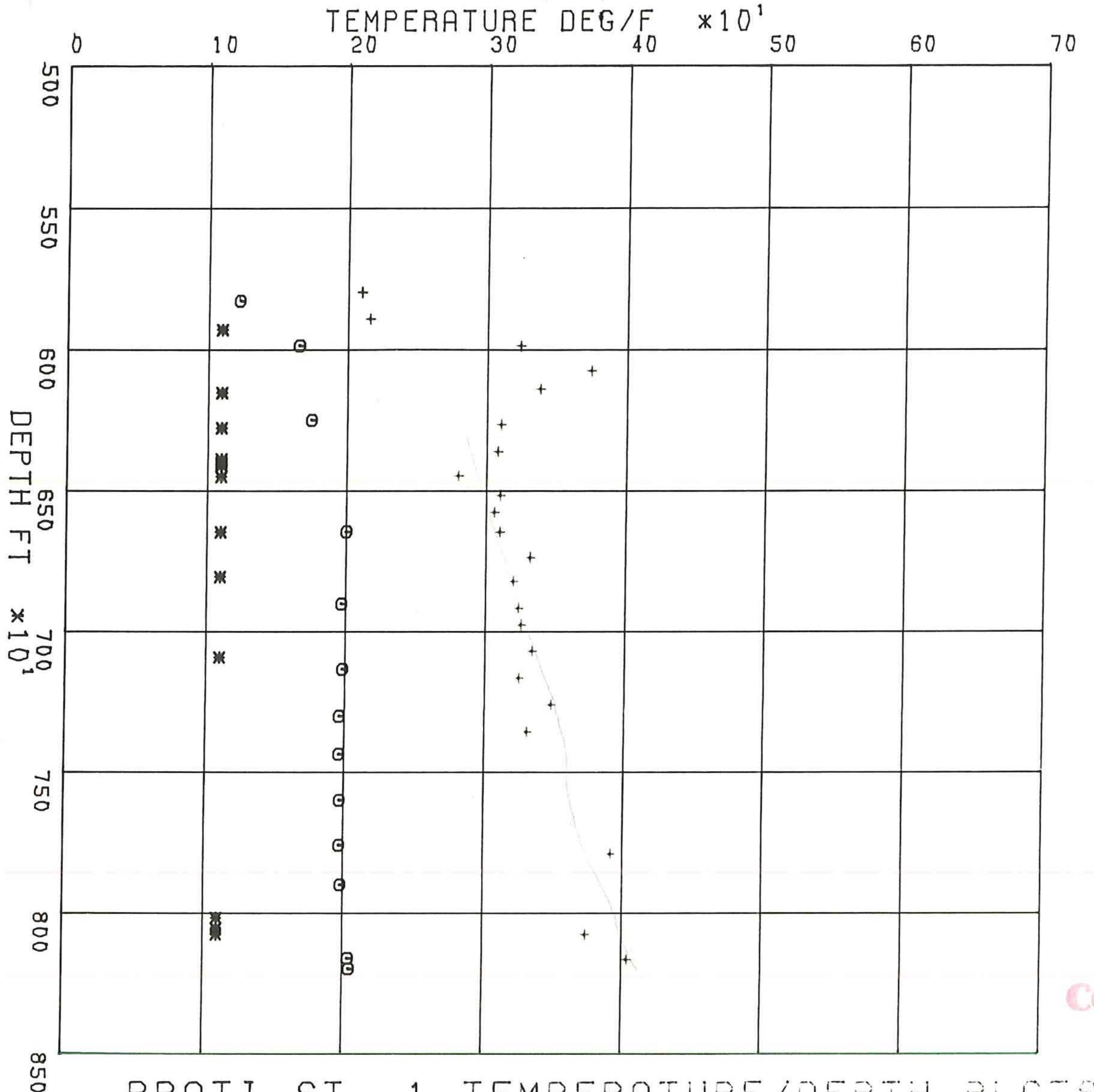

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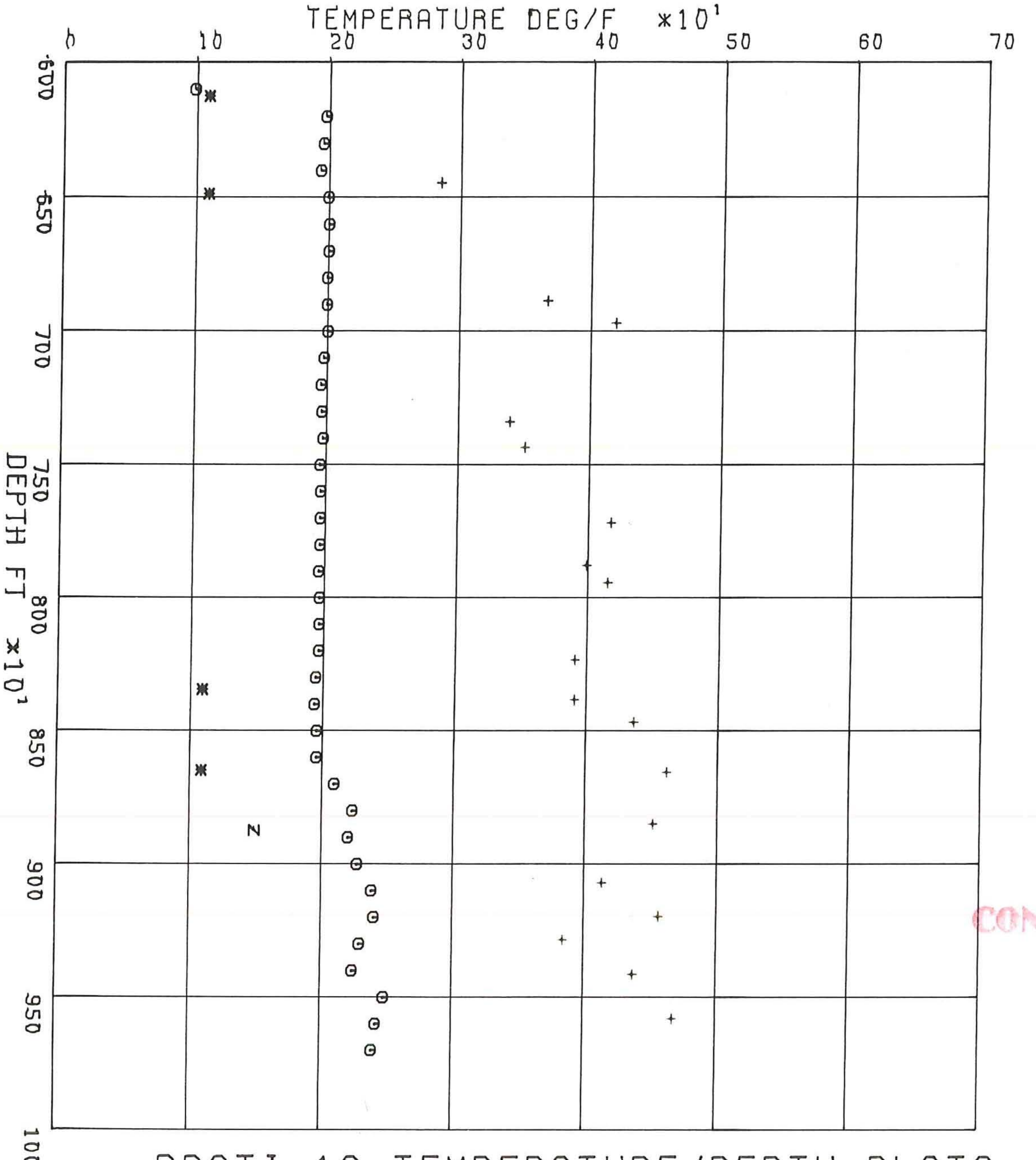
PRATI ST. 1 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



PRATI 1A TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

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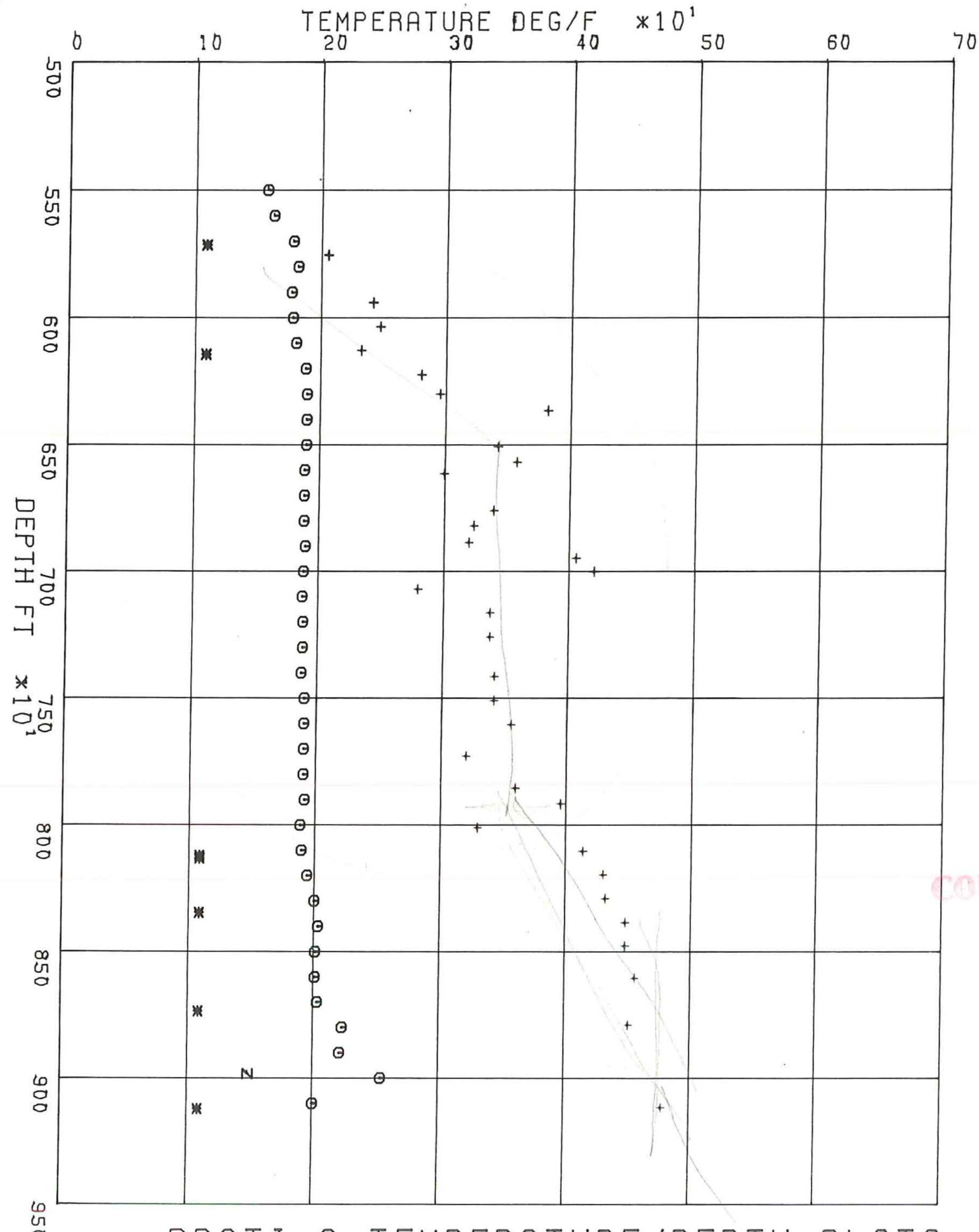

PRATI 2 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

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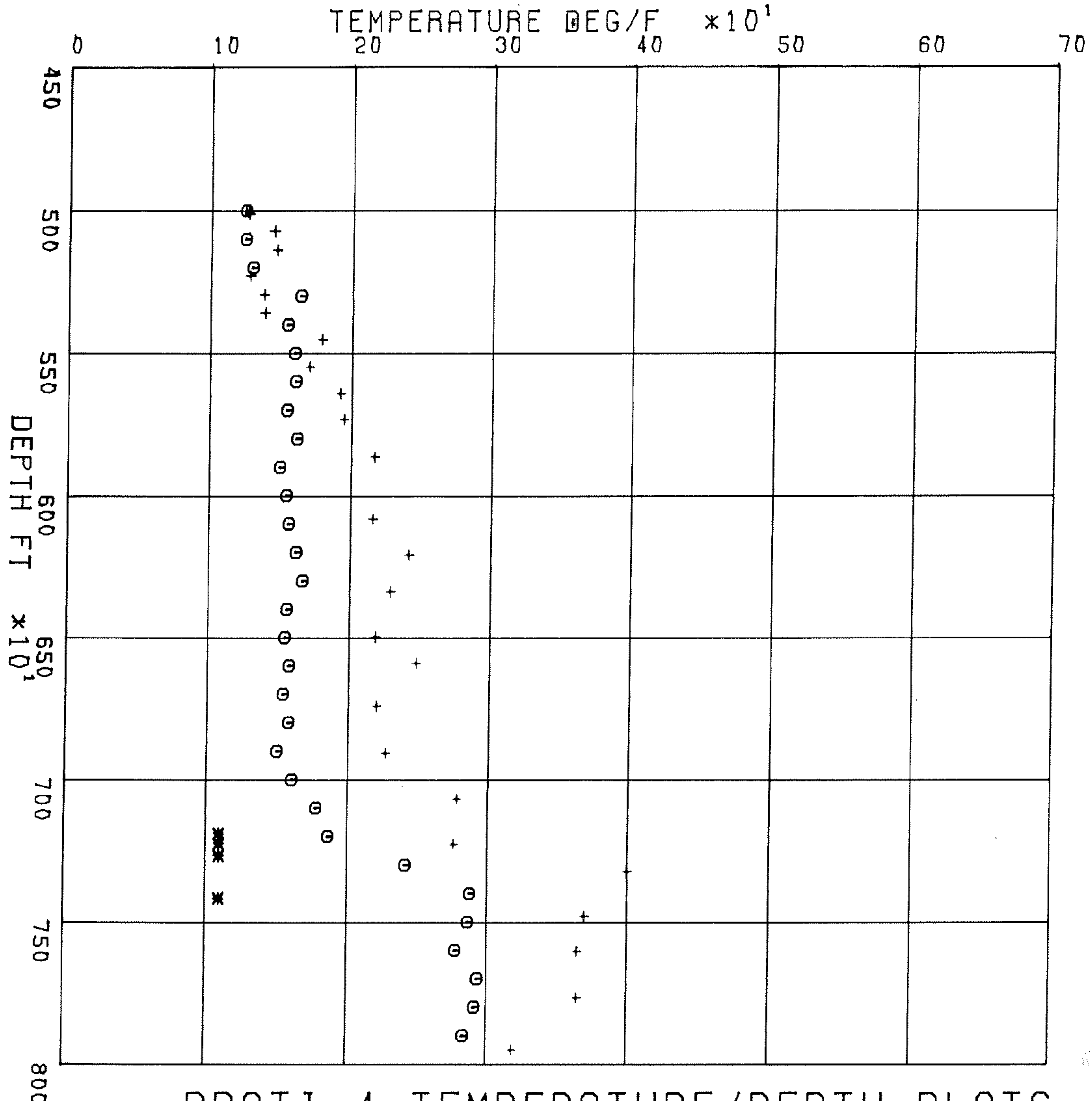
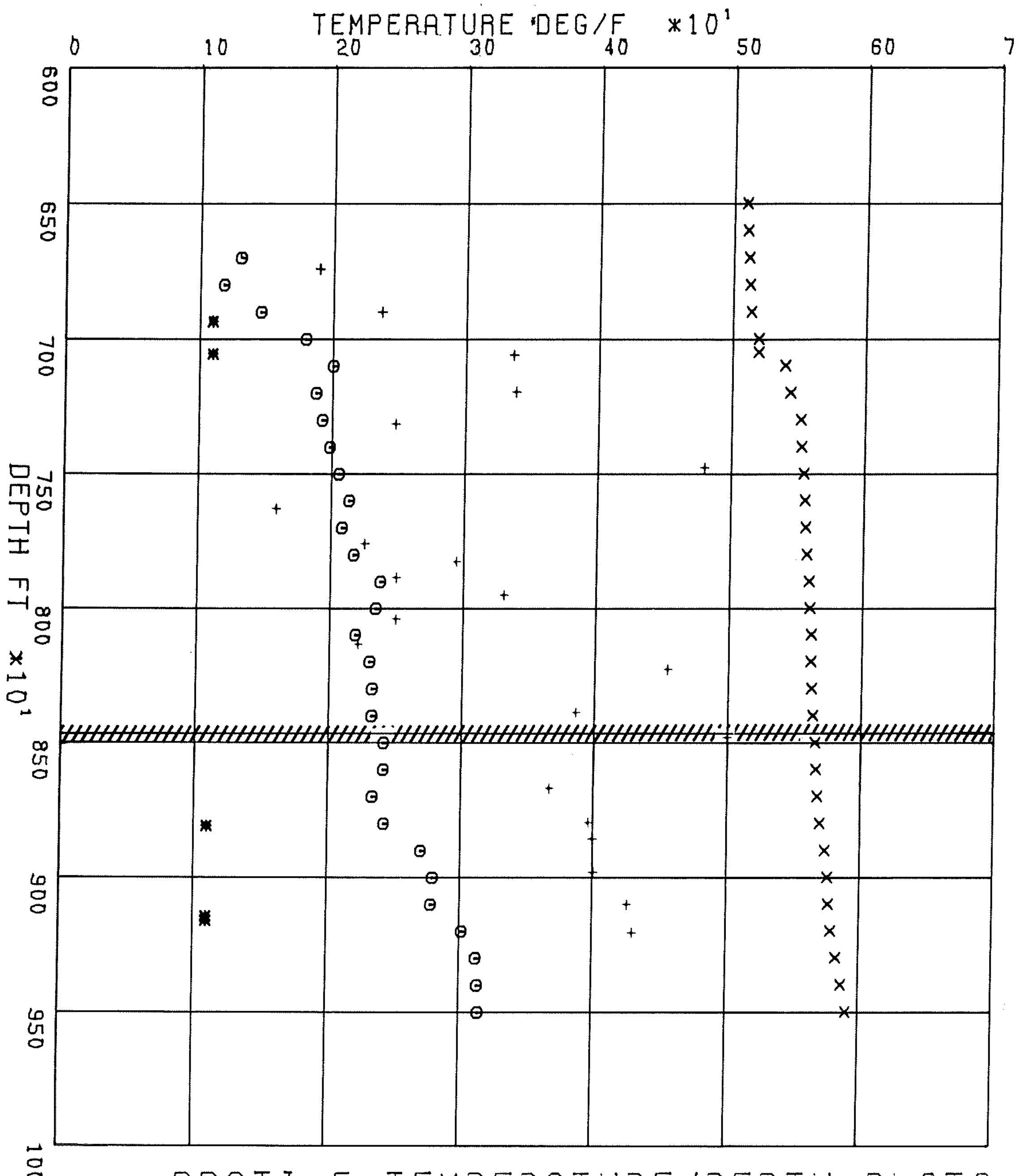


PRATI 4 TEMPERATURE/DEPTH PLOTS

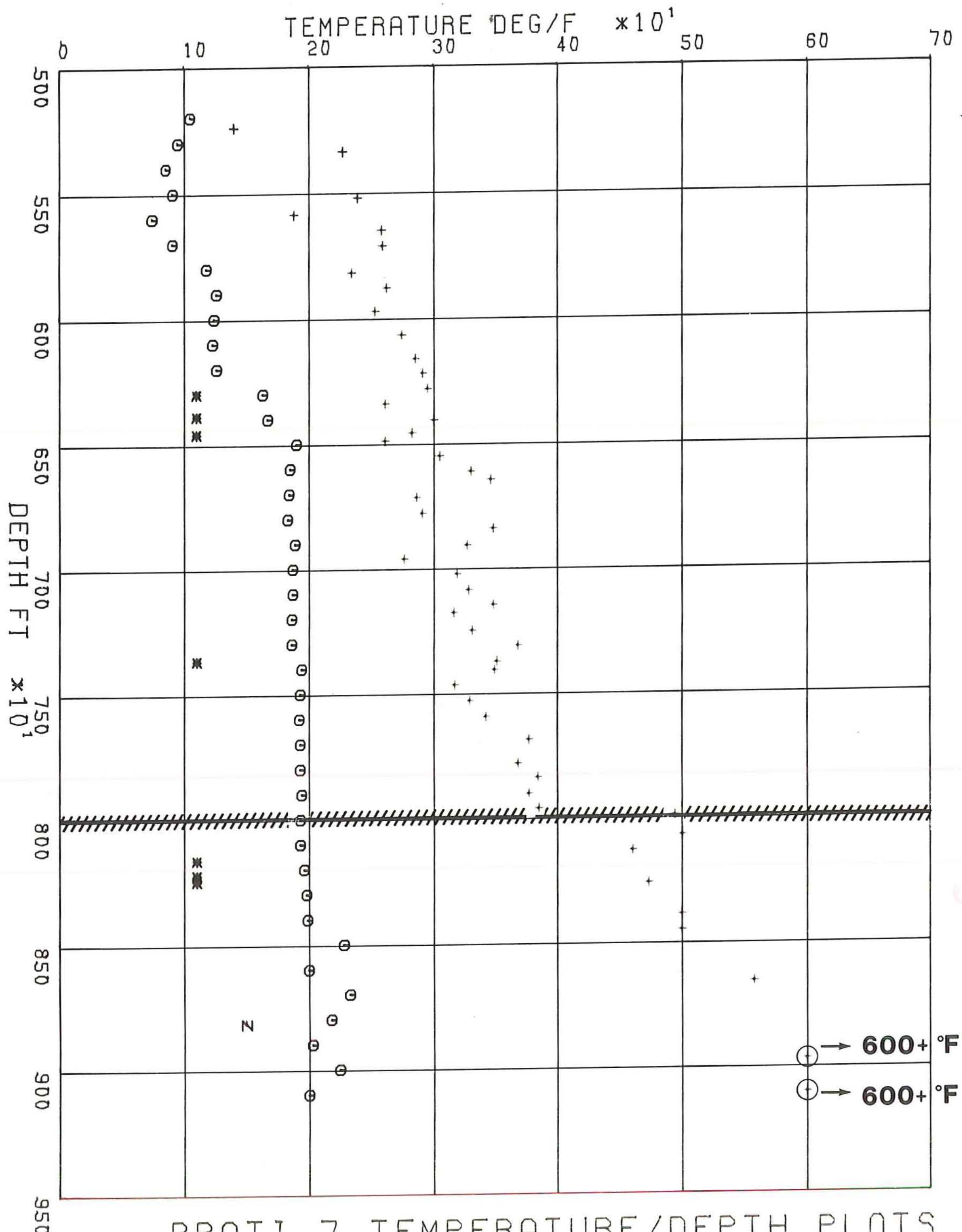
X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



PRATI 5 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// - **Est. Top of High Temperature Reservoir**



PRATI 7 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// - **Est. Top of High Temperature Reservoir**

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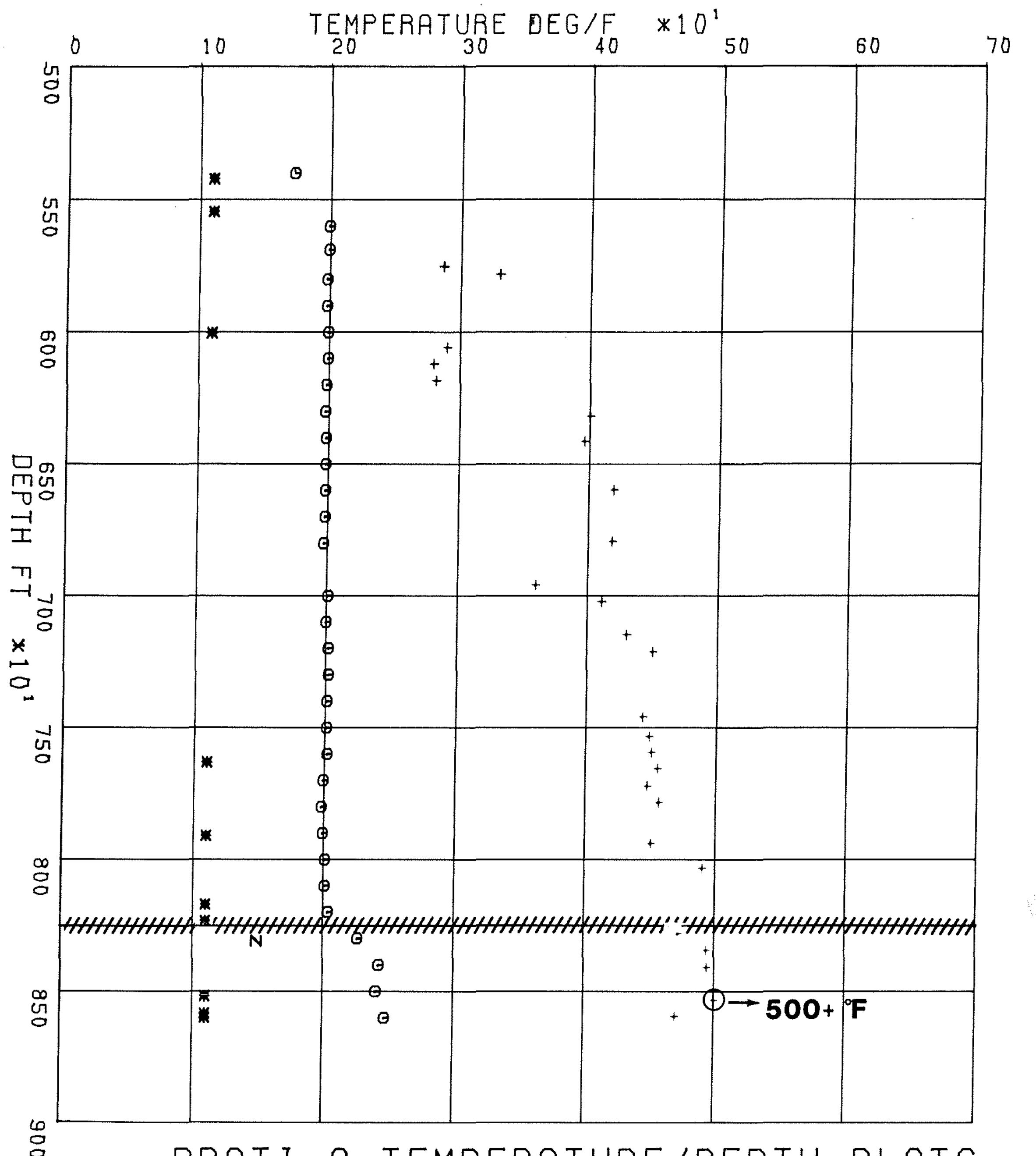

PRATI 8 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// - **Est. Top of High Temperature Reservoir**

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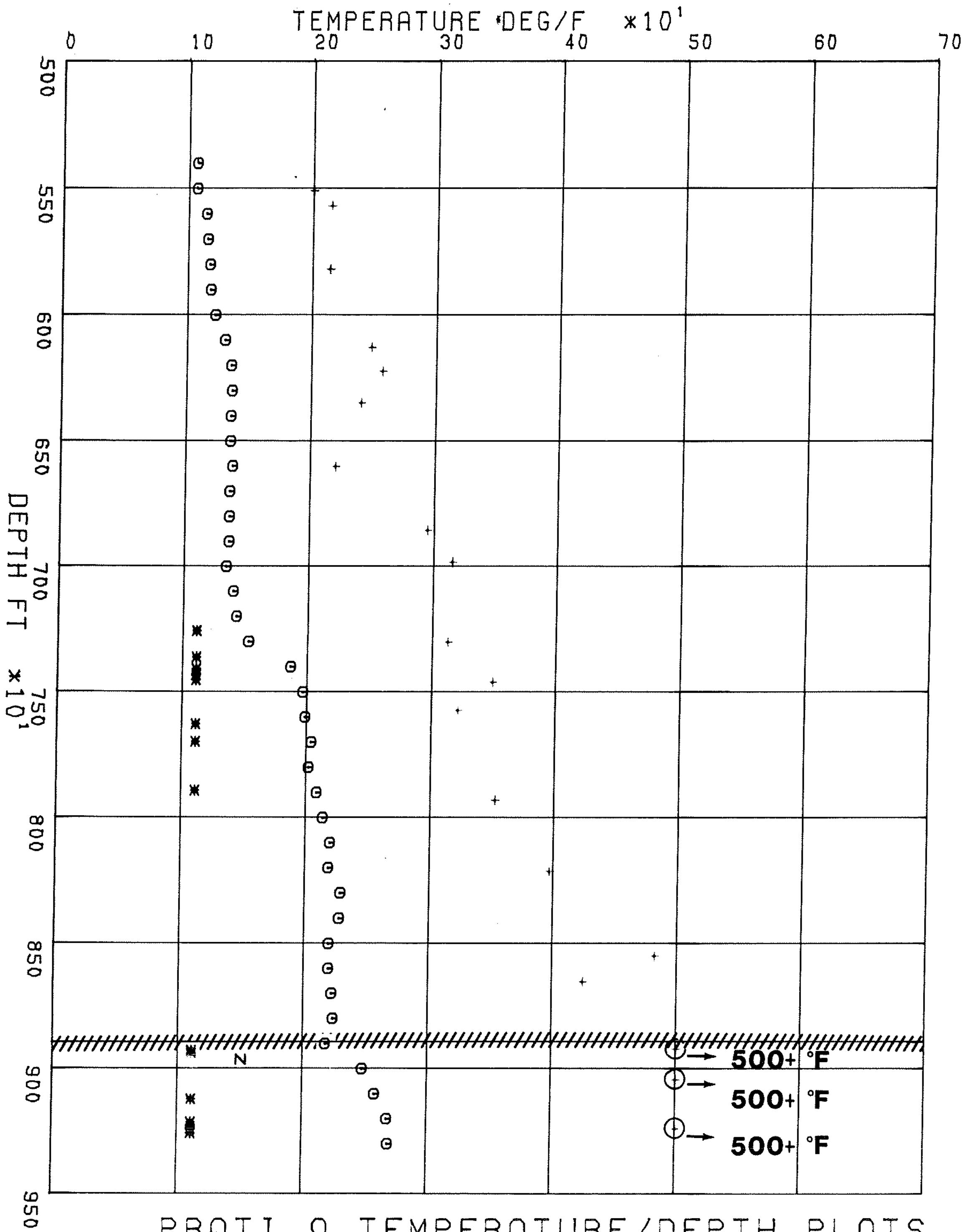
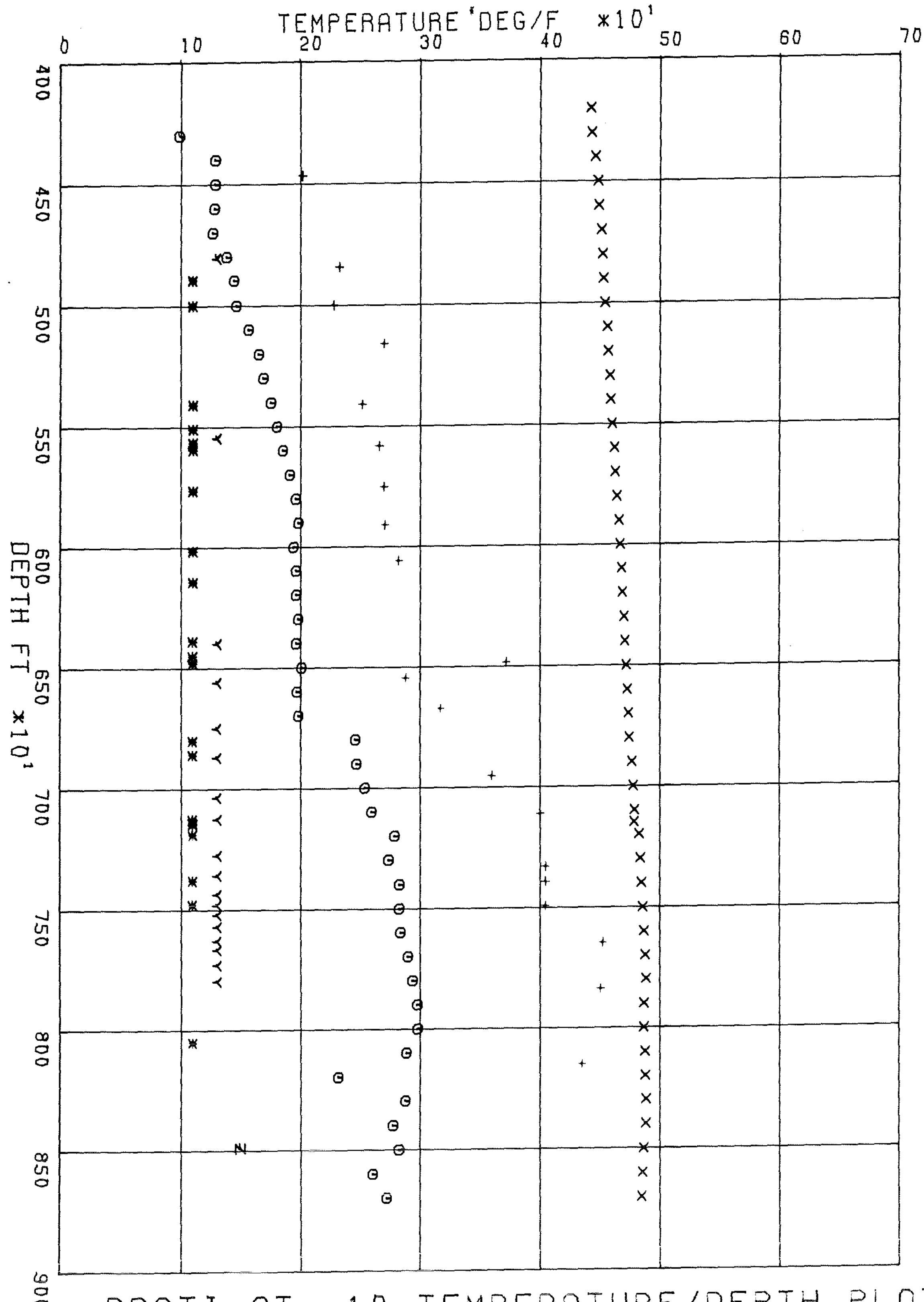


PRATI 9 TEMPERATURE/DEPTH PLOTS

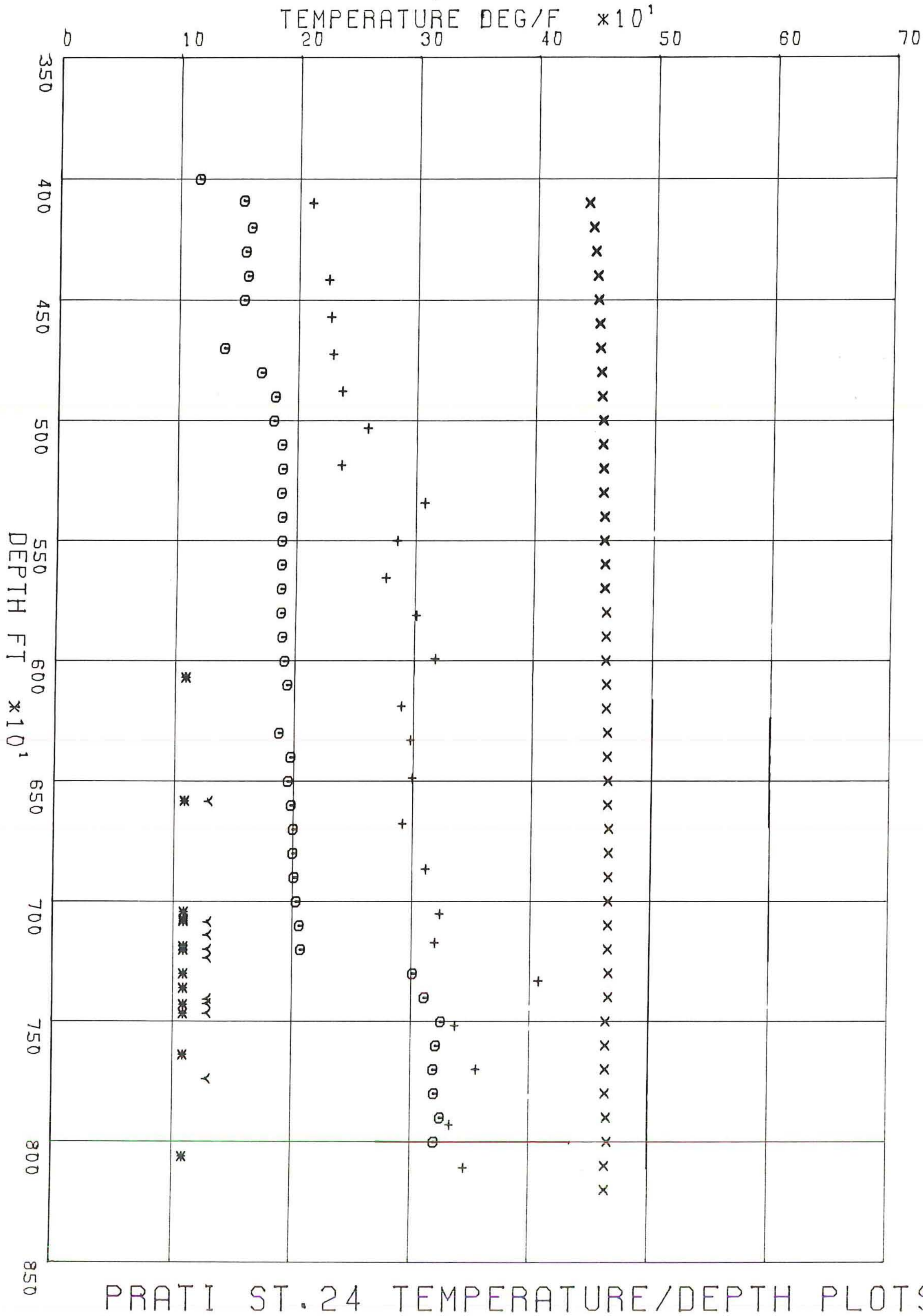
X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**



PRATI ST. 10 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



PRATI ST.24 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

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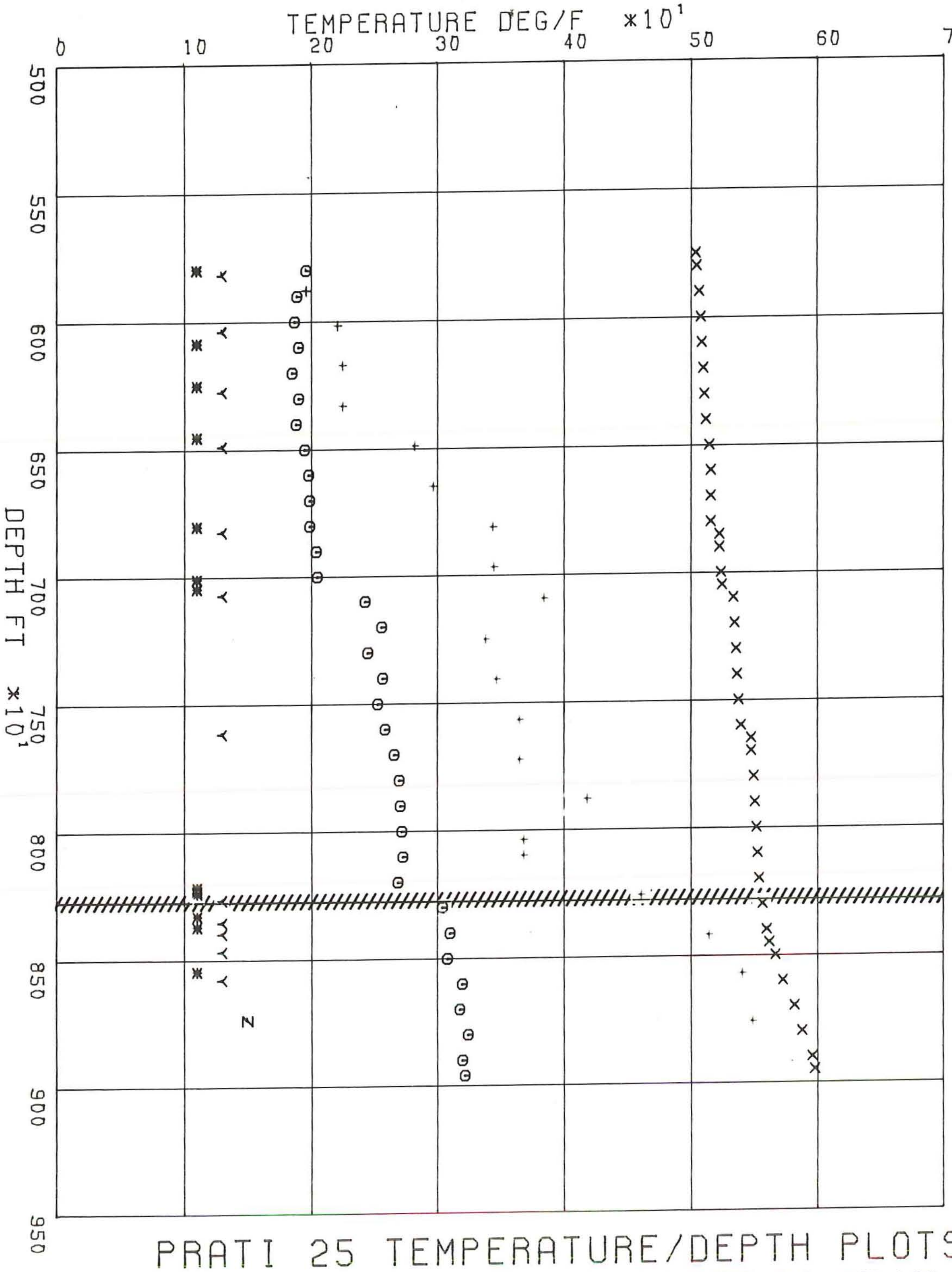
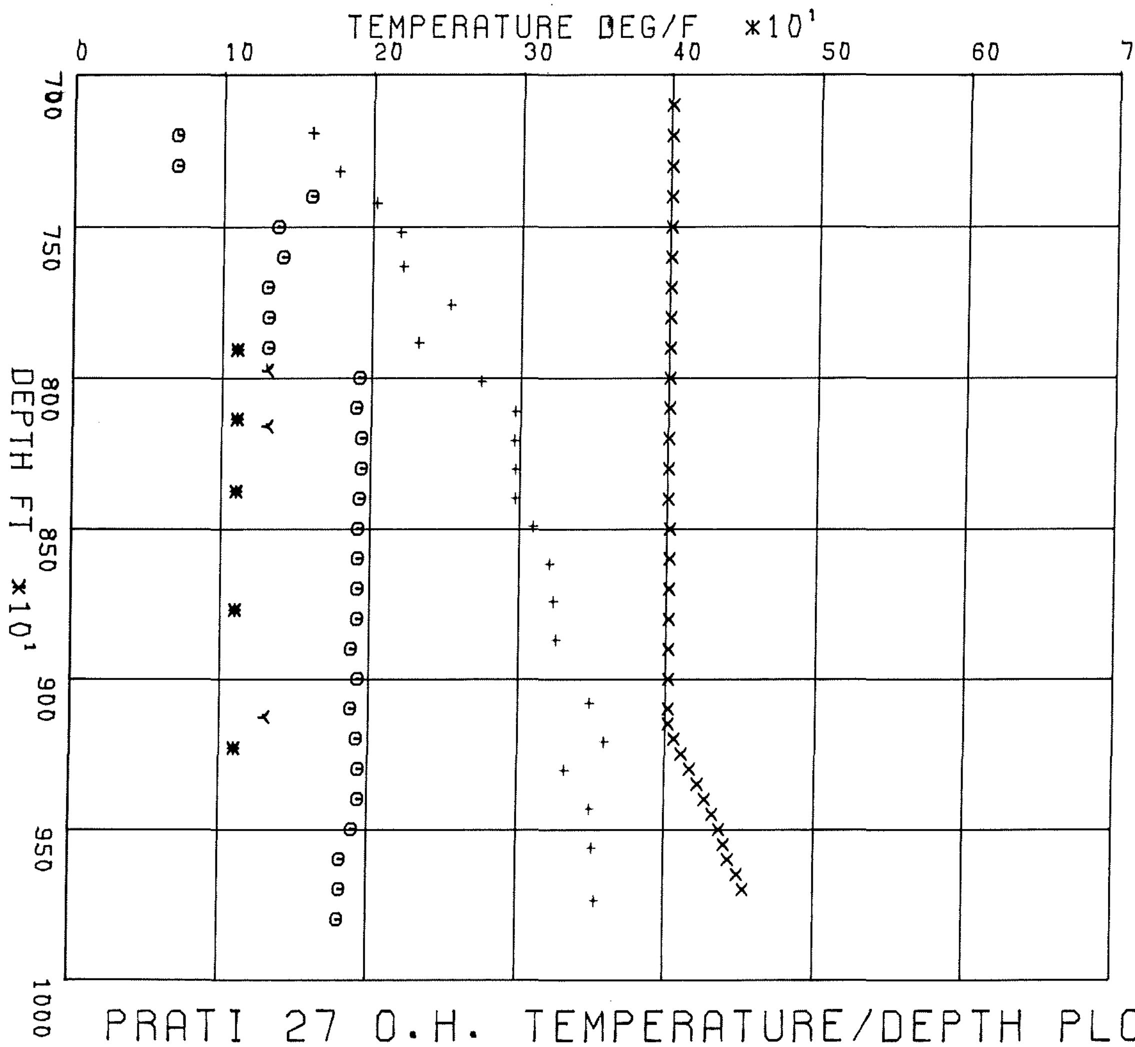


PRATI 25 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// - **Est. Top of High Temperature Reservoir**



PRATI 27 O.H. TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

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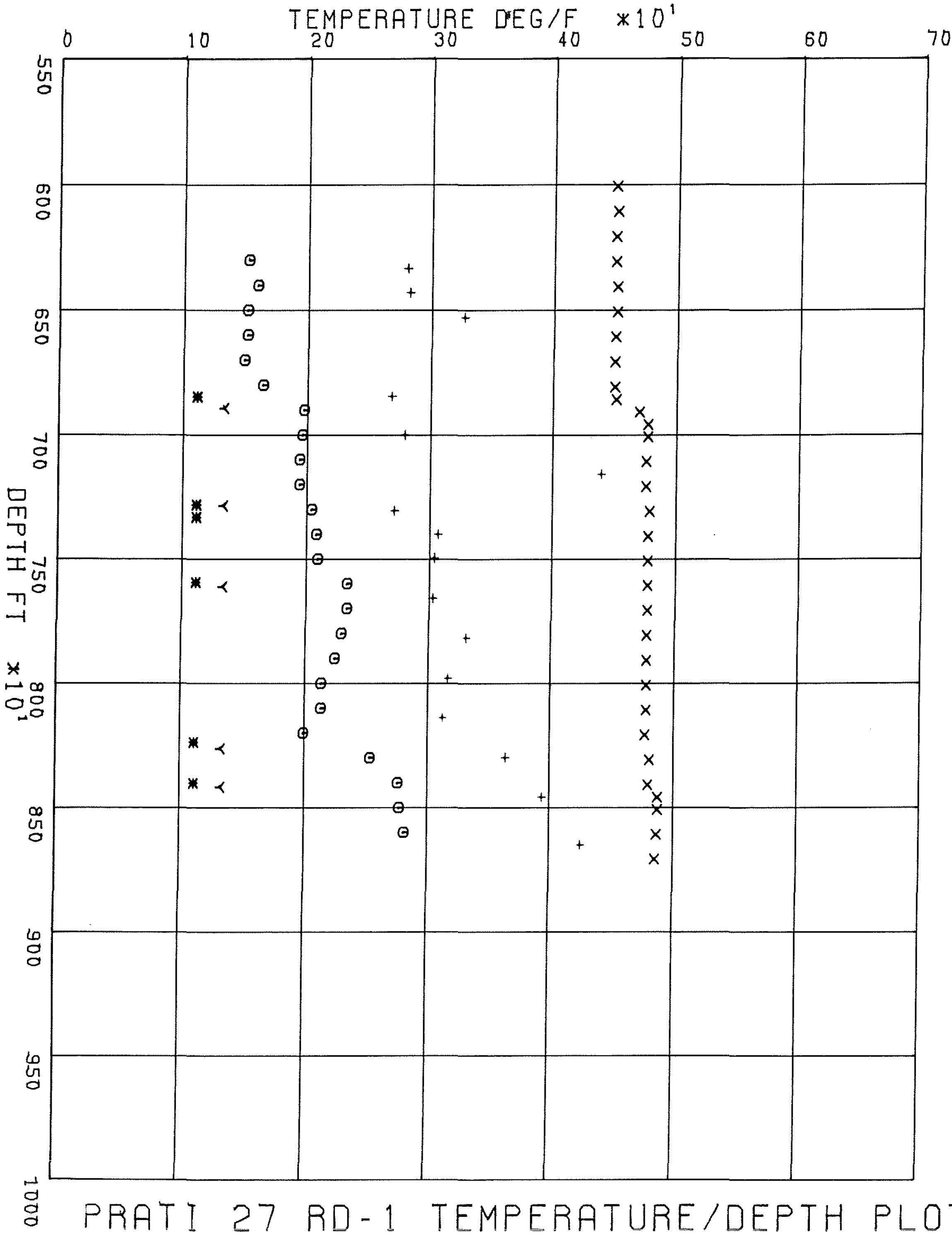

PRATI 27 RD-1 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

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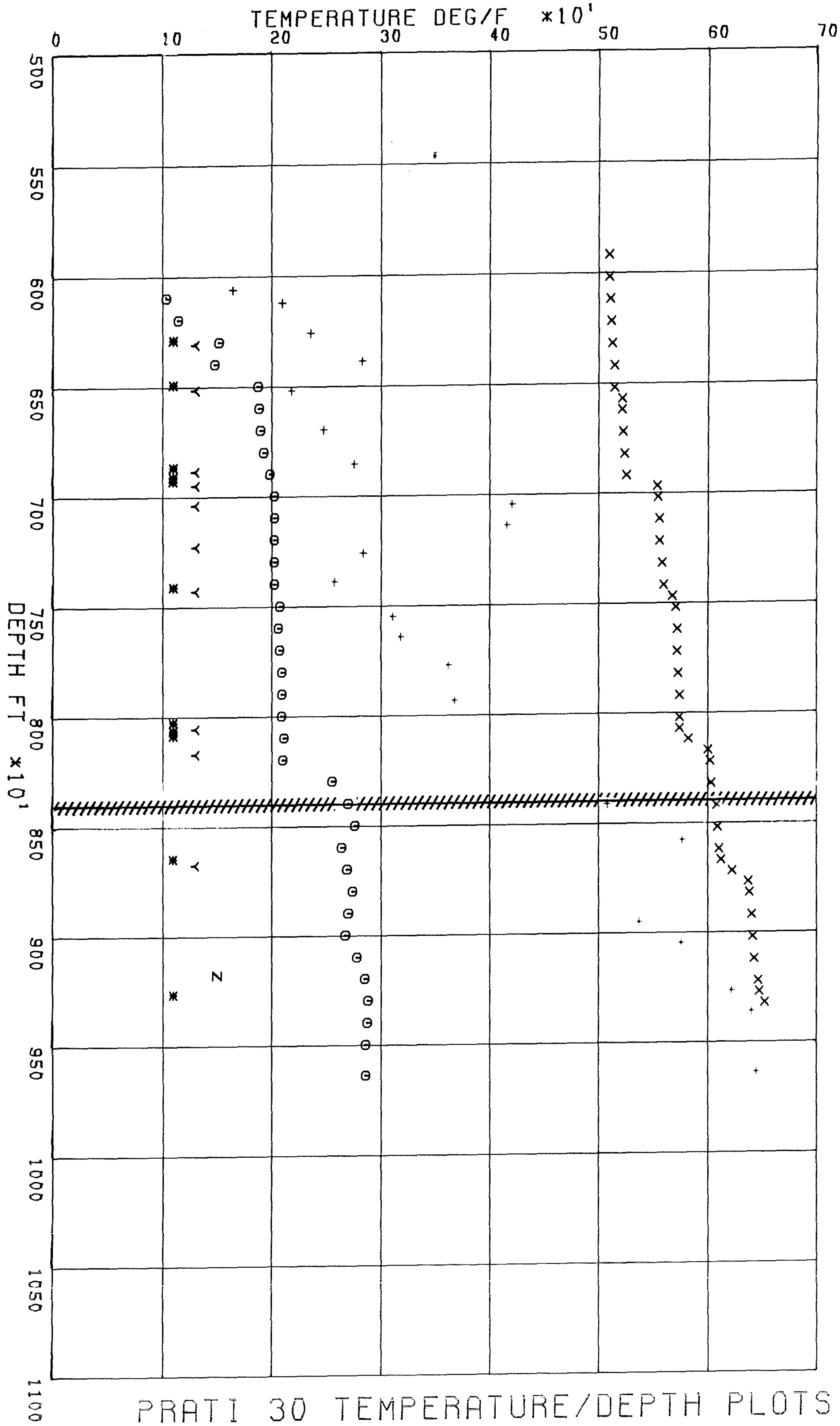
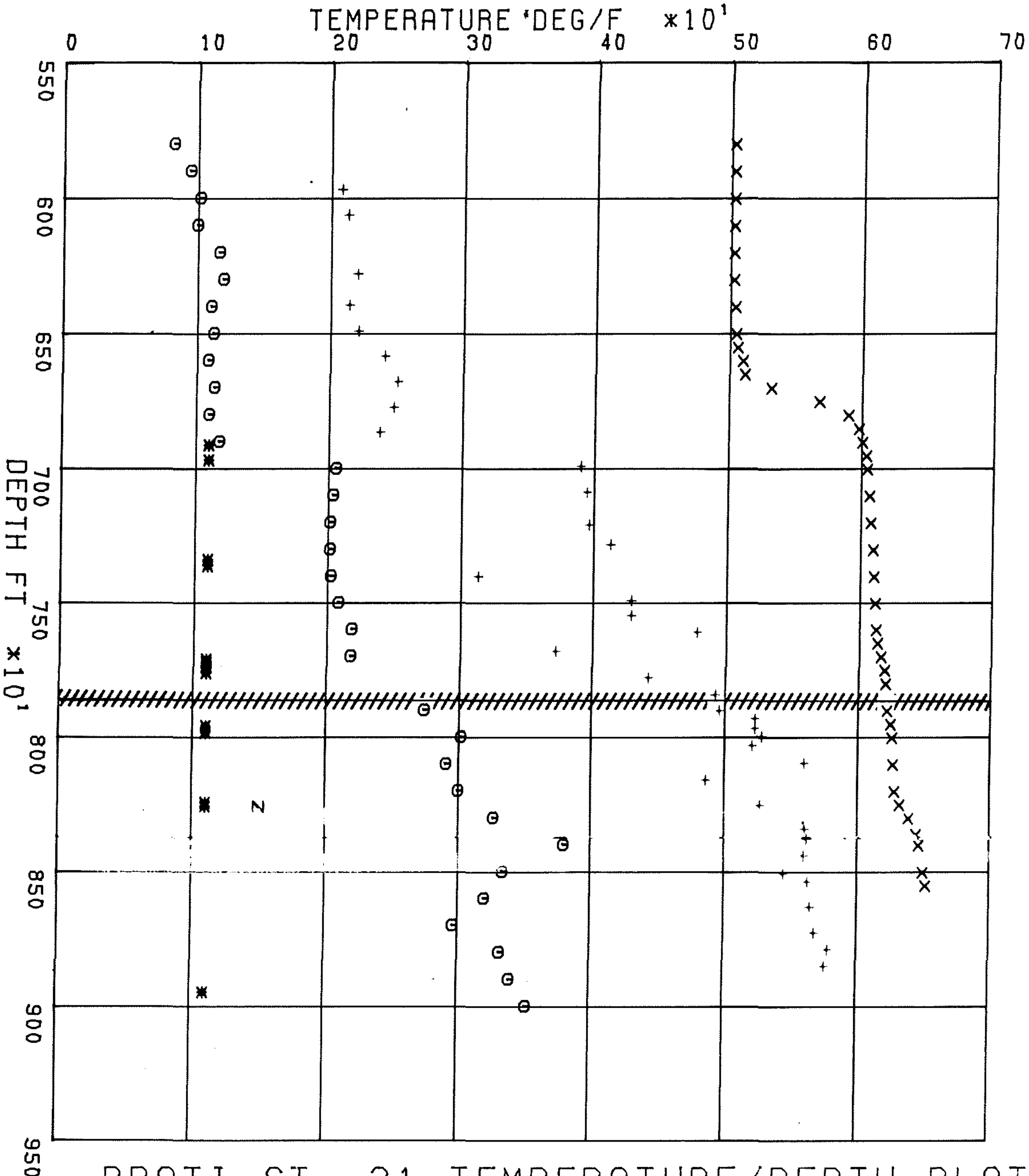


PRATI 30 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



PRATI ST. 31 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**

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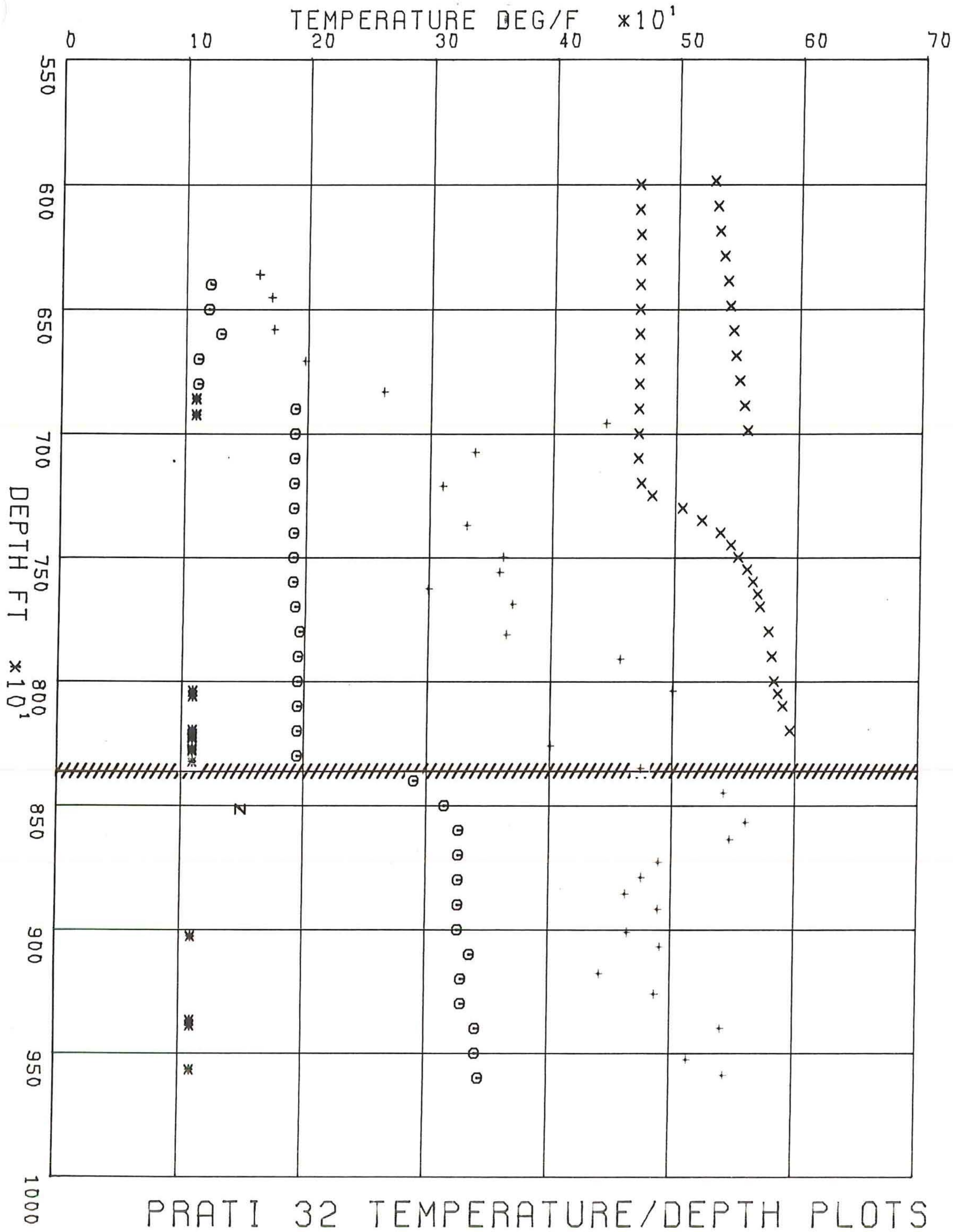

PRATI 32 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// - **Est. Top of High Temperature Reservoir**

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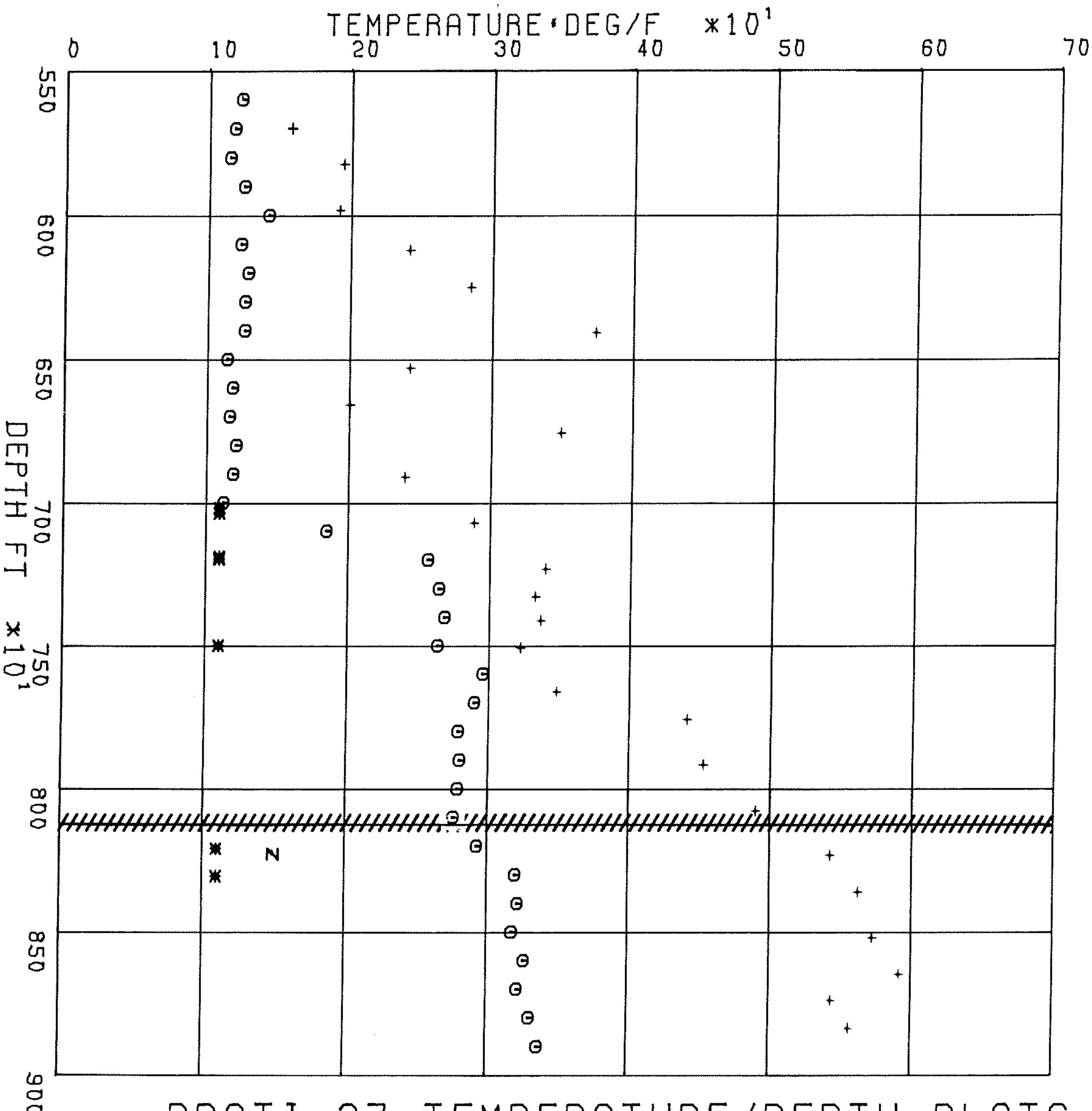
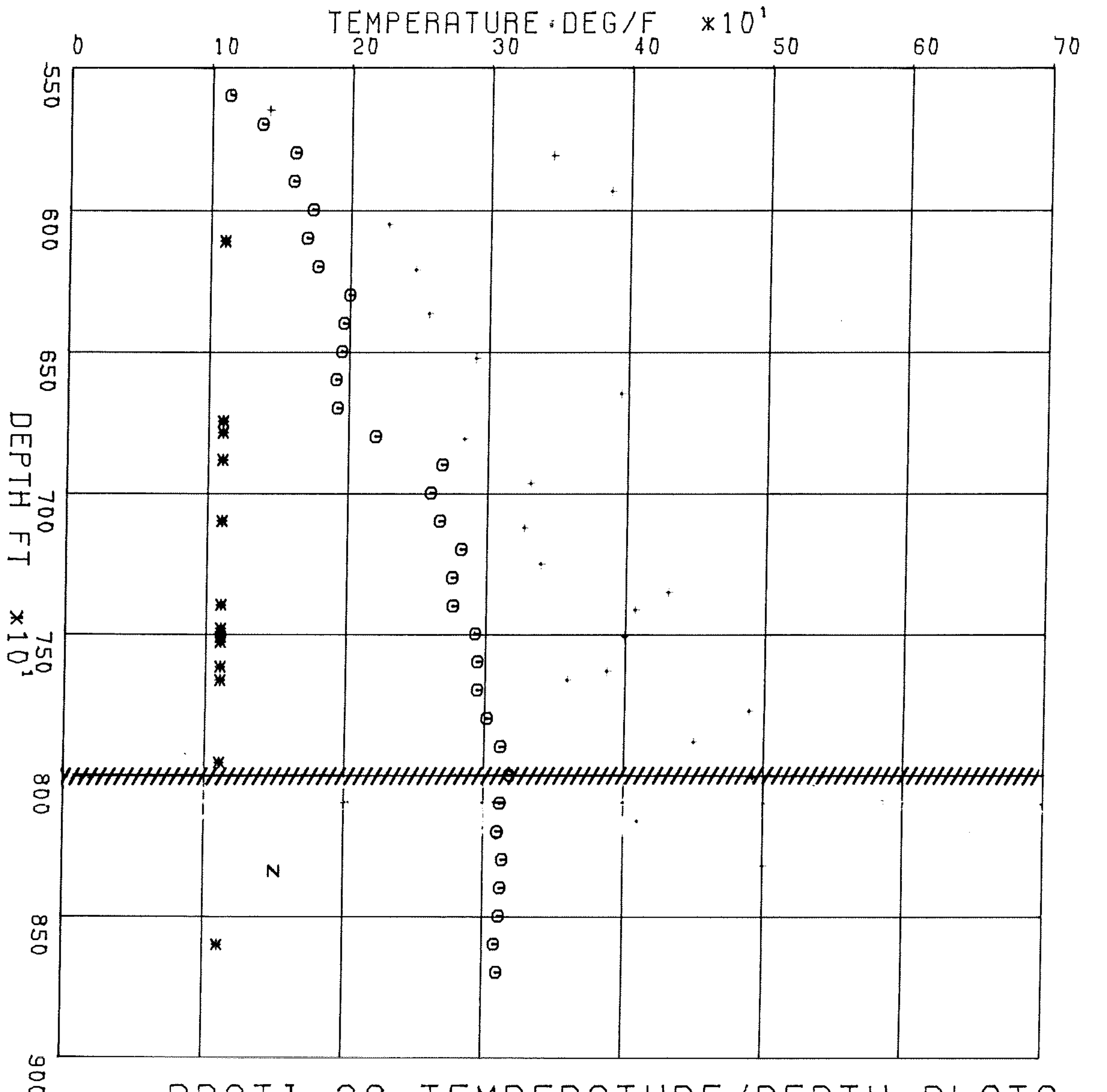


PRATI 37 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

//////////////////// **- Est. Top of High Temperature Reservoir**

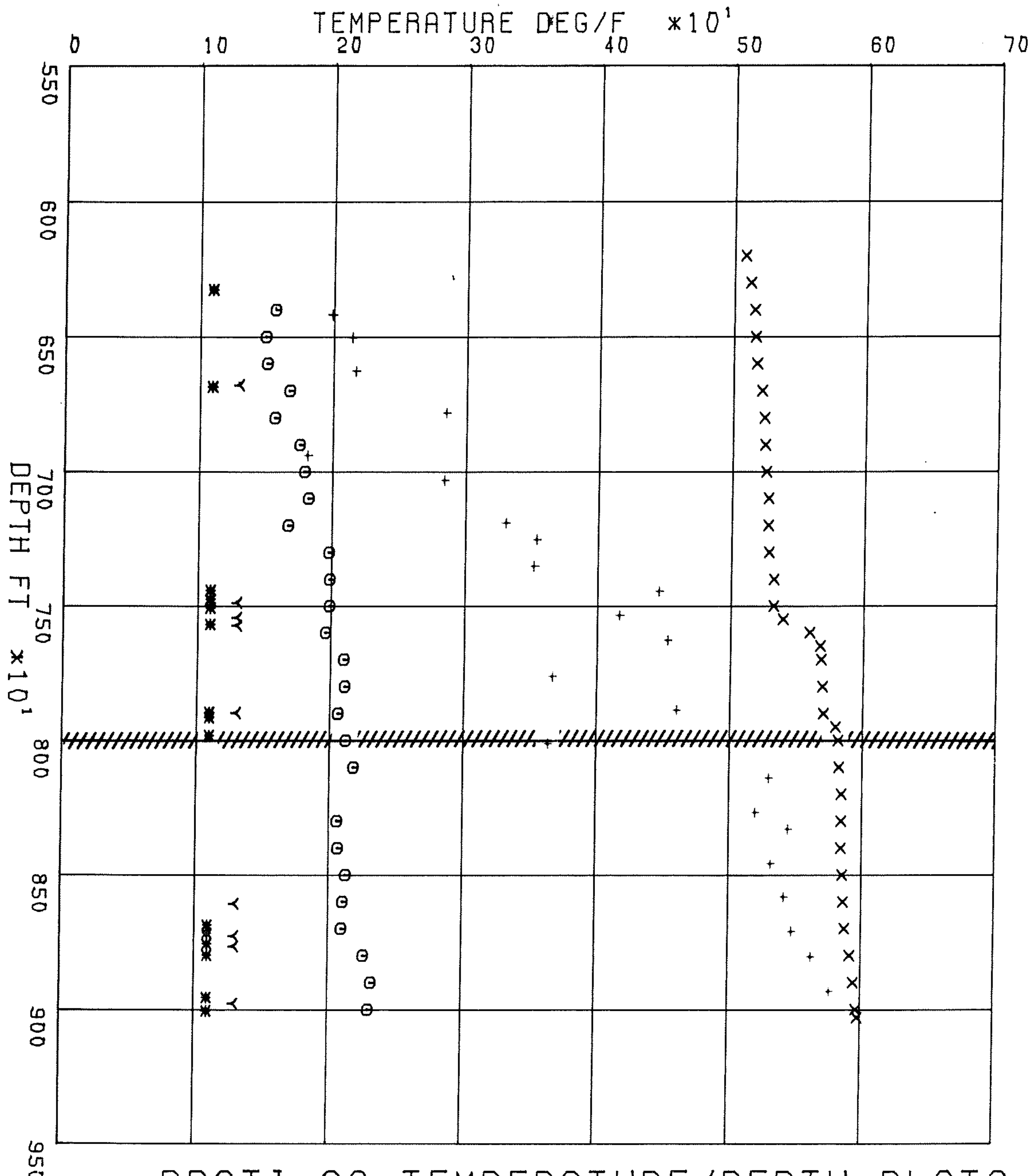
...ENTIAL



PRATI 38 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**



PRATI 39 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

//////////////////// **- Est. Top of High Temperature Reservoir**

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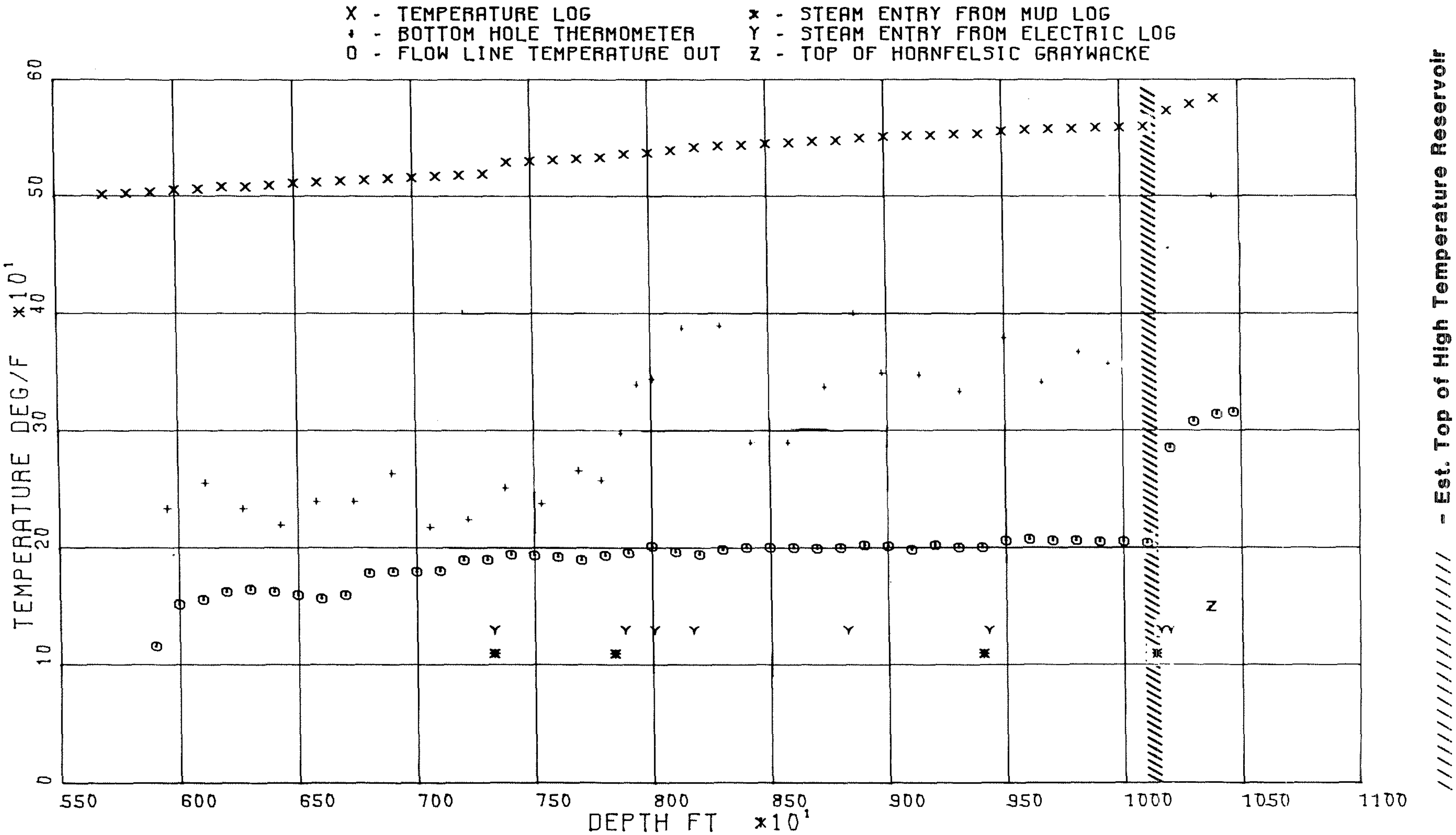
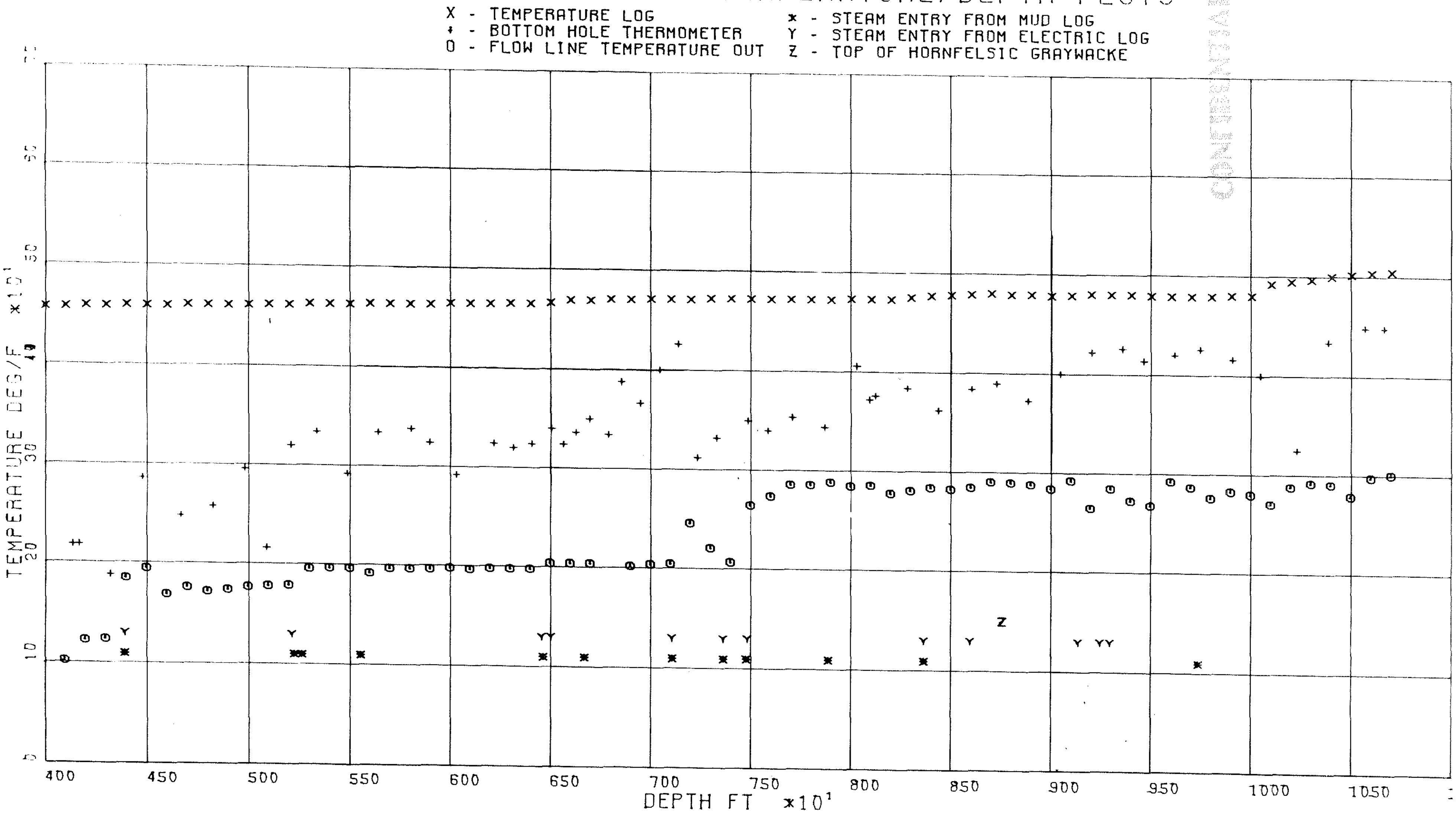
PRATI 50 TEMPERATURE/DEPTH PLOTS



PRATI STATE 54 TEMPERATURE/DEPTH PLOTS



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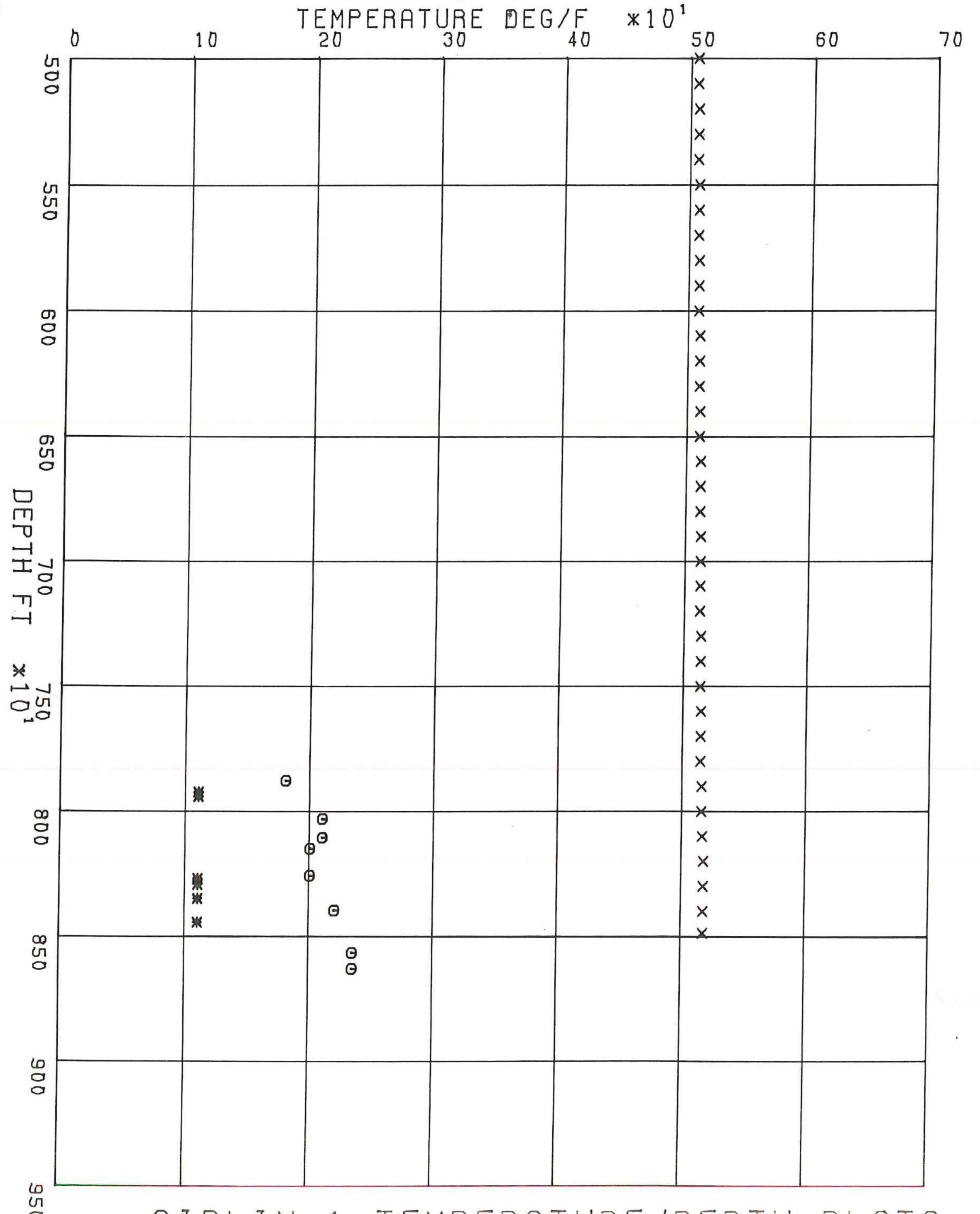
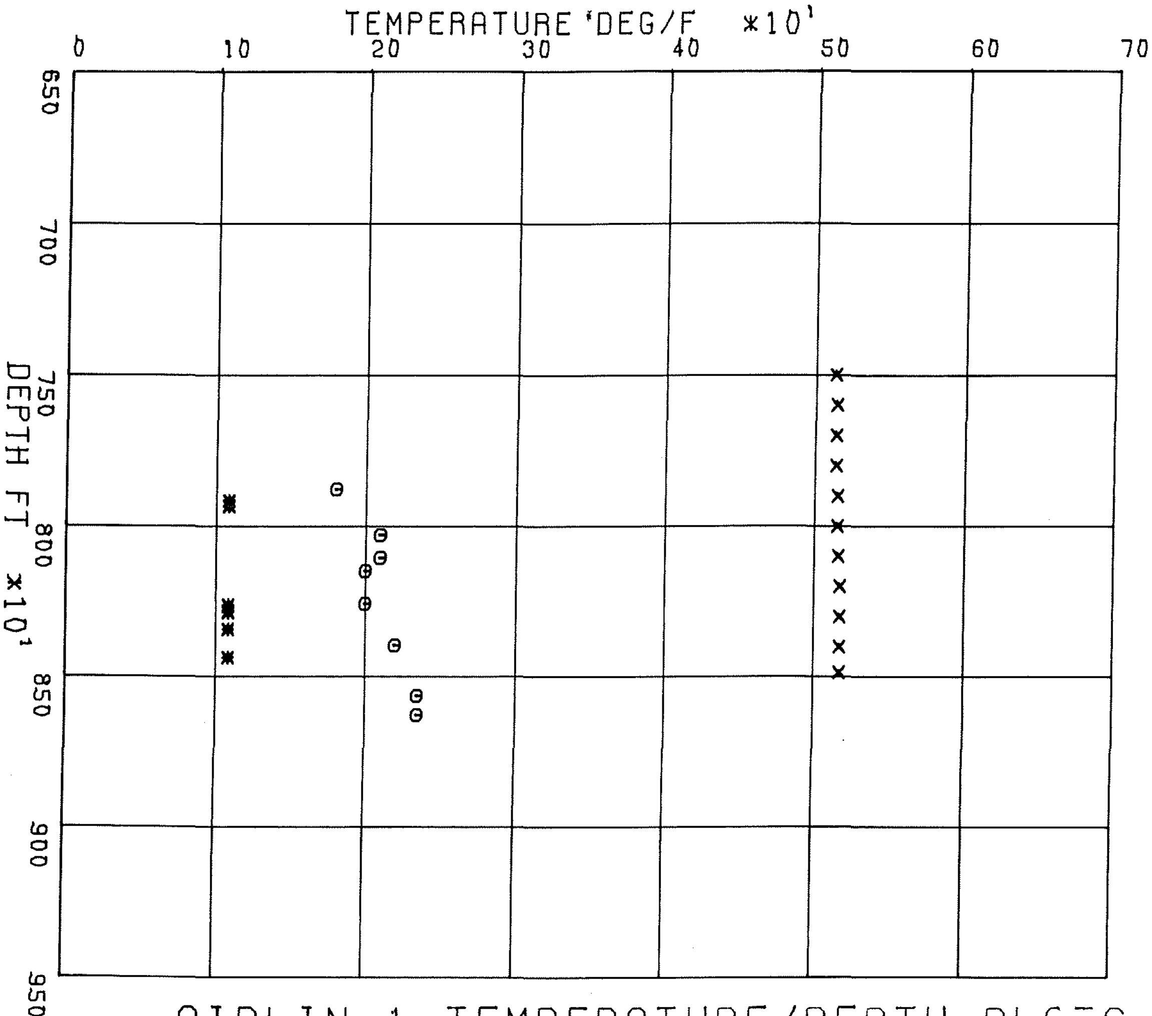


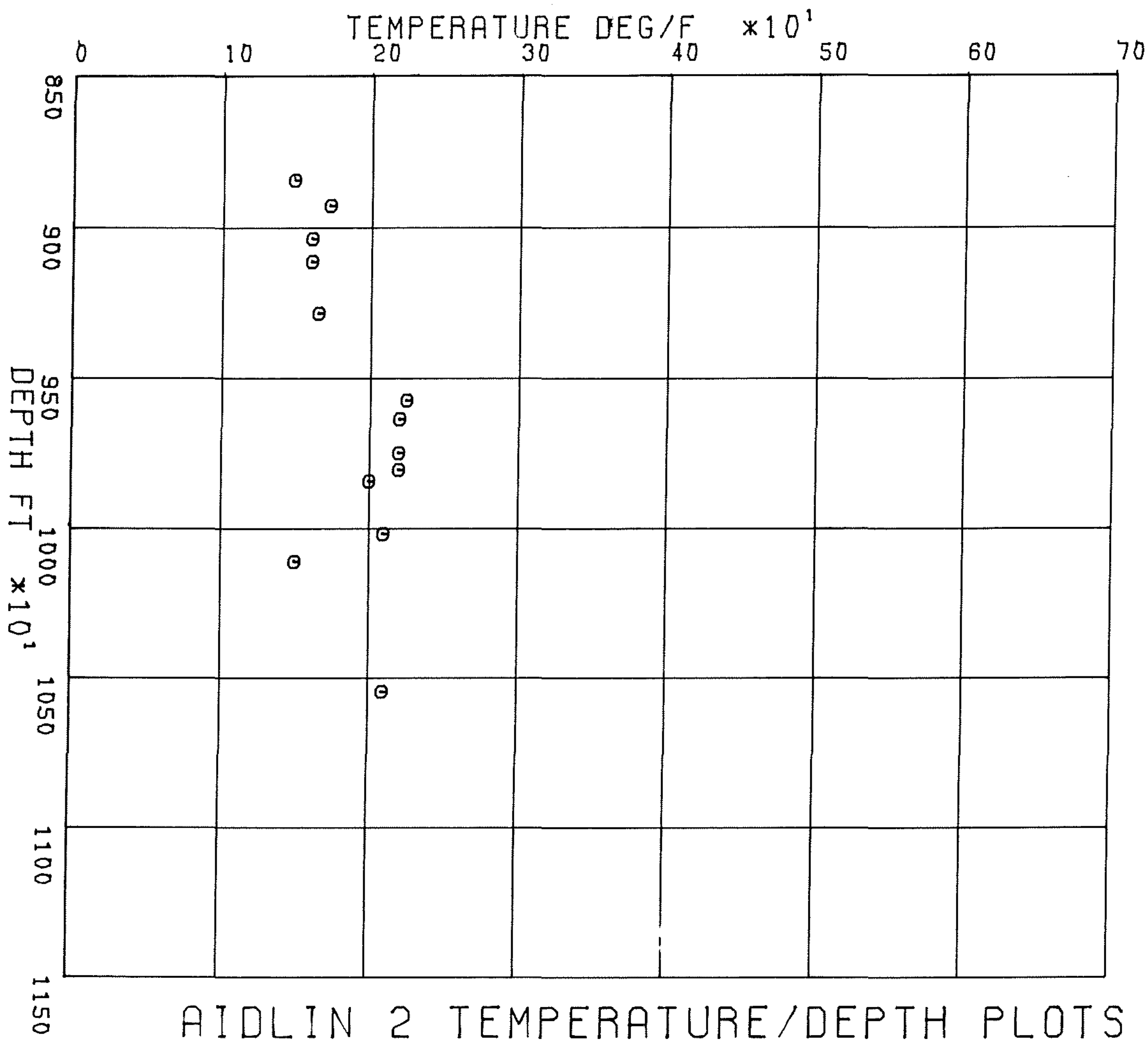
AIDLIN 1 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



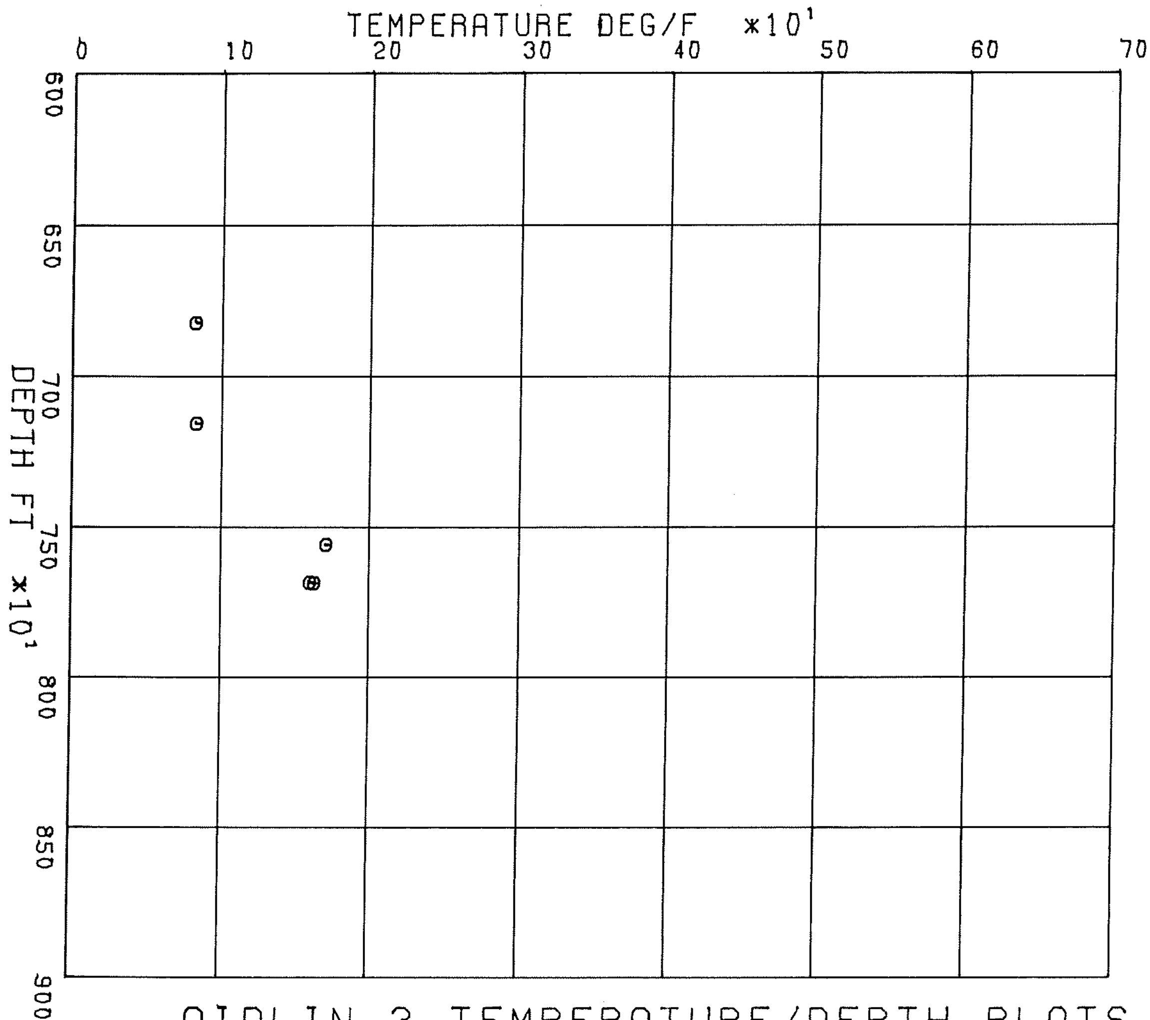
AIDLIN 1 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



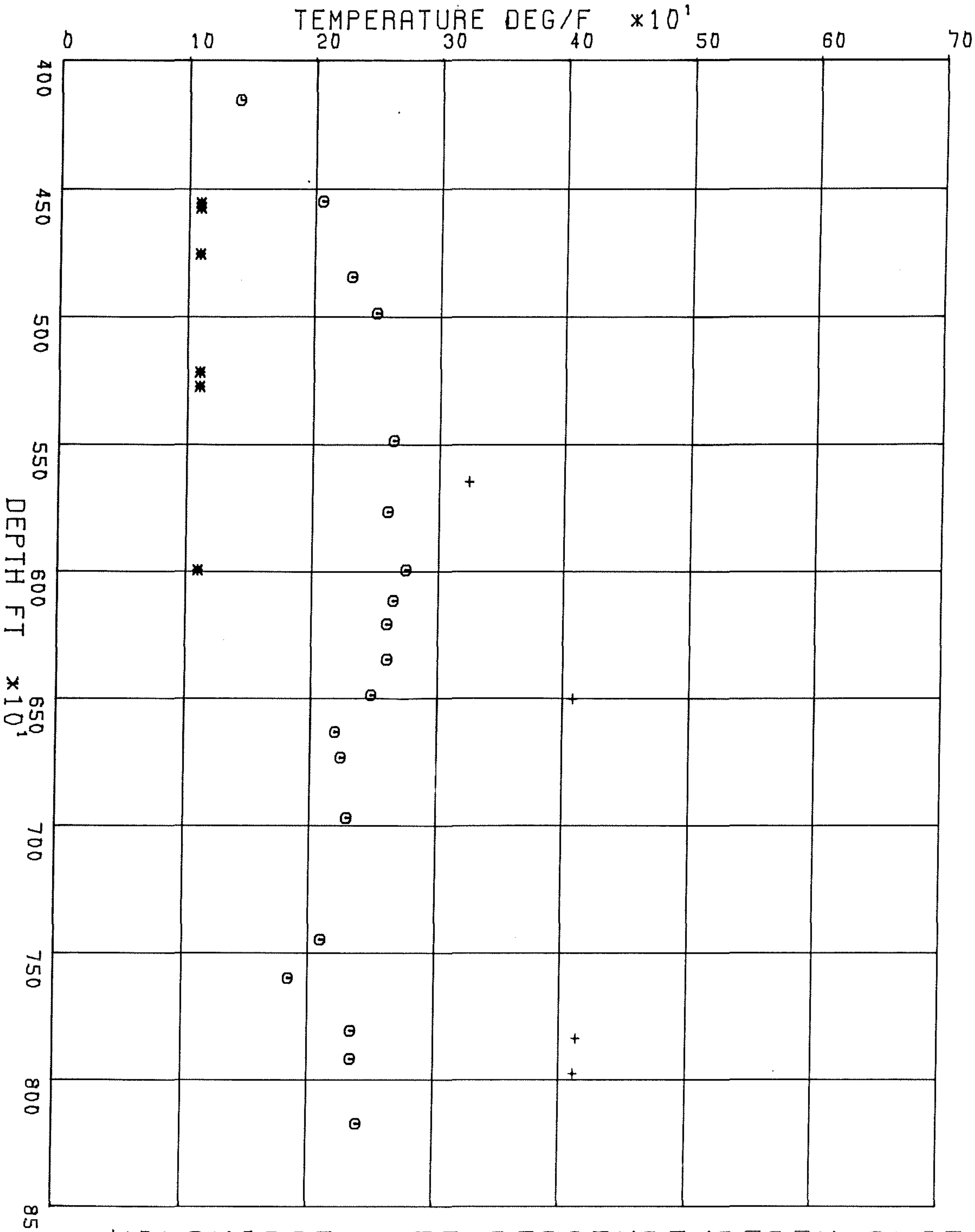
AIDLIN 2 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



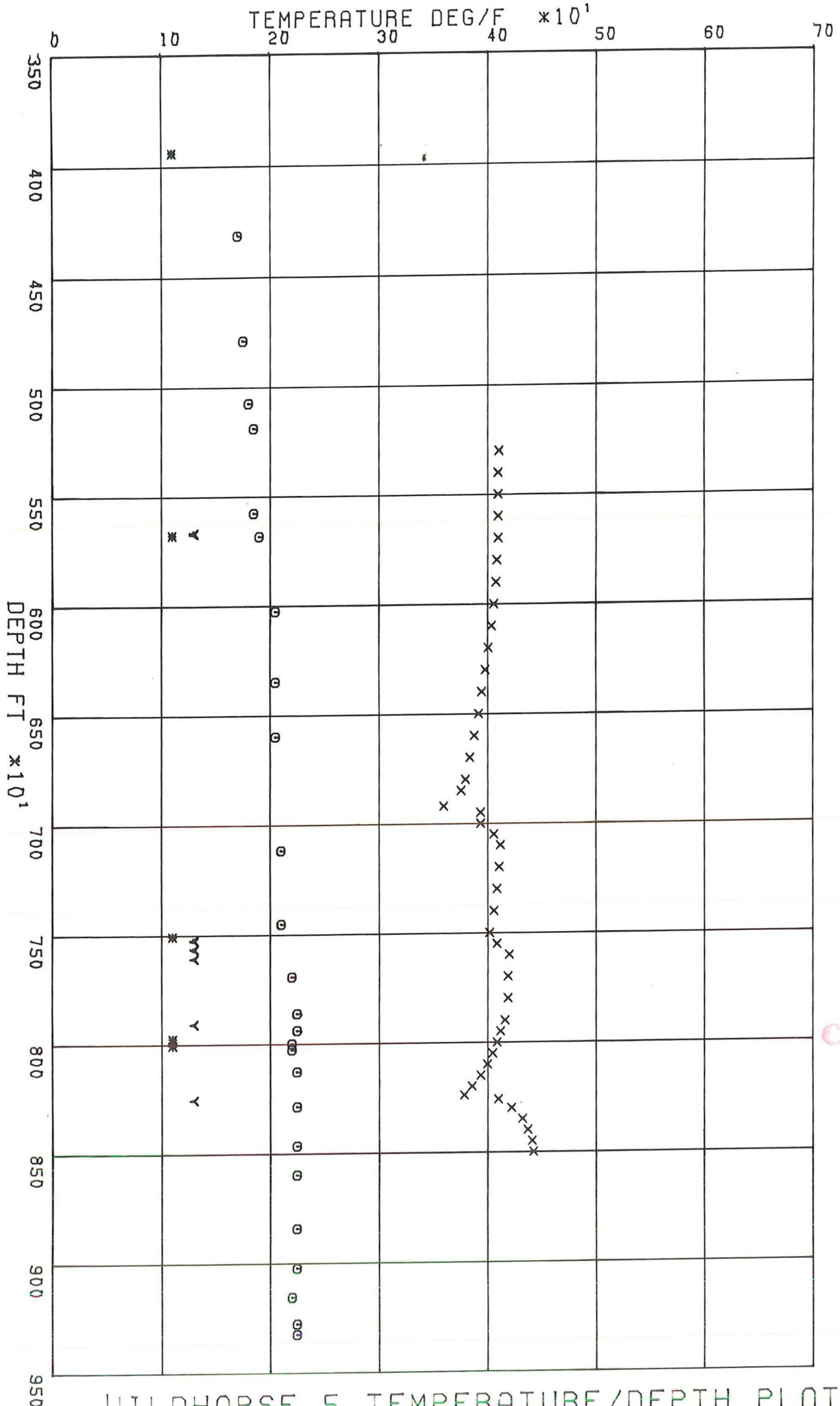
AIDLIN 3 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



WILDHORSE 1 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



WILDHORSE 5 TEMPERATURE/DEPTH PLOTS

X - TEMPERATURE LOG
+ - BOTTOM HOLE THERMOMETER
O - FLOW LINE TEMPERATURE OUT
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

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APPENDIX VI

GAS-DEPTH PLOTS FOR GEOOC WELLS IN AREAS A-1, A-2, 3

Notes:

1. Only Exlog/Smith H_2S and CO_2 data for wells which penetrate the high temperature reservoir are plotted.
2. Gas values for wells which don't penetrate the high temperature reservoir are available in Table II.

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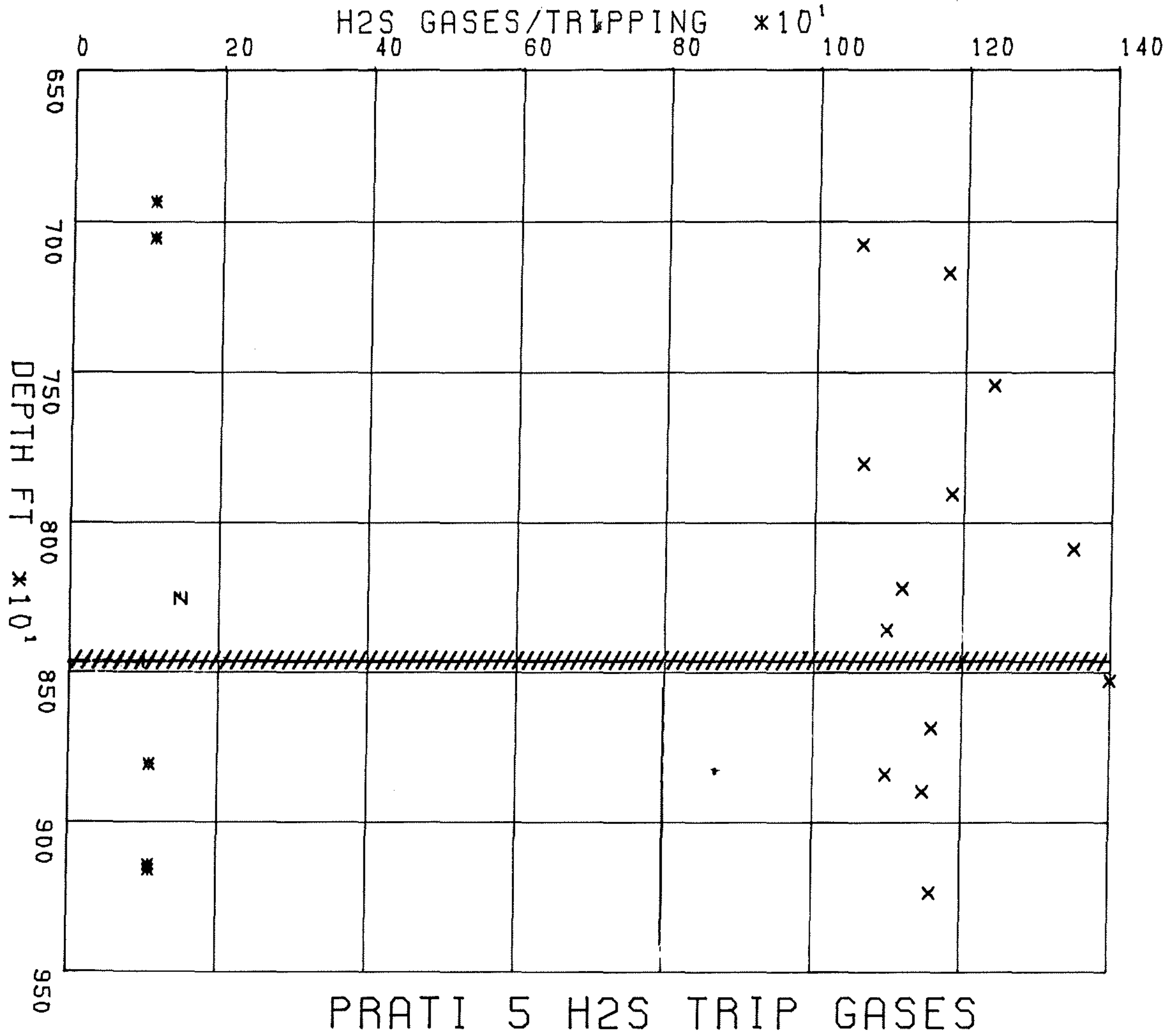

PRATI 5 H2S TRIP GASES

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

//////////////////// **- Est. Top of High Temperature Reservoir**

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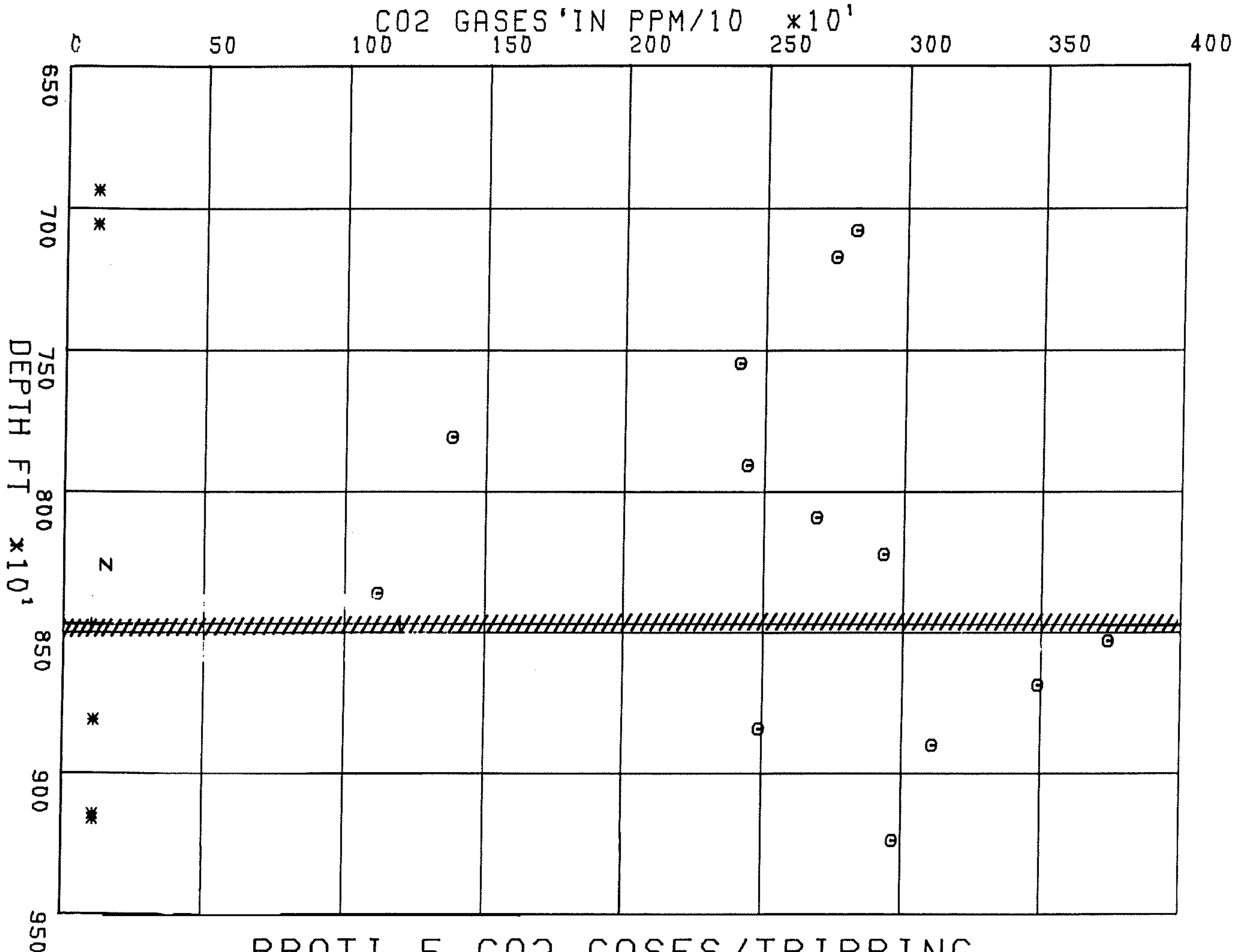
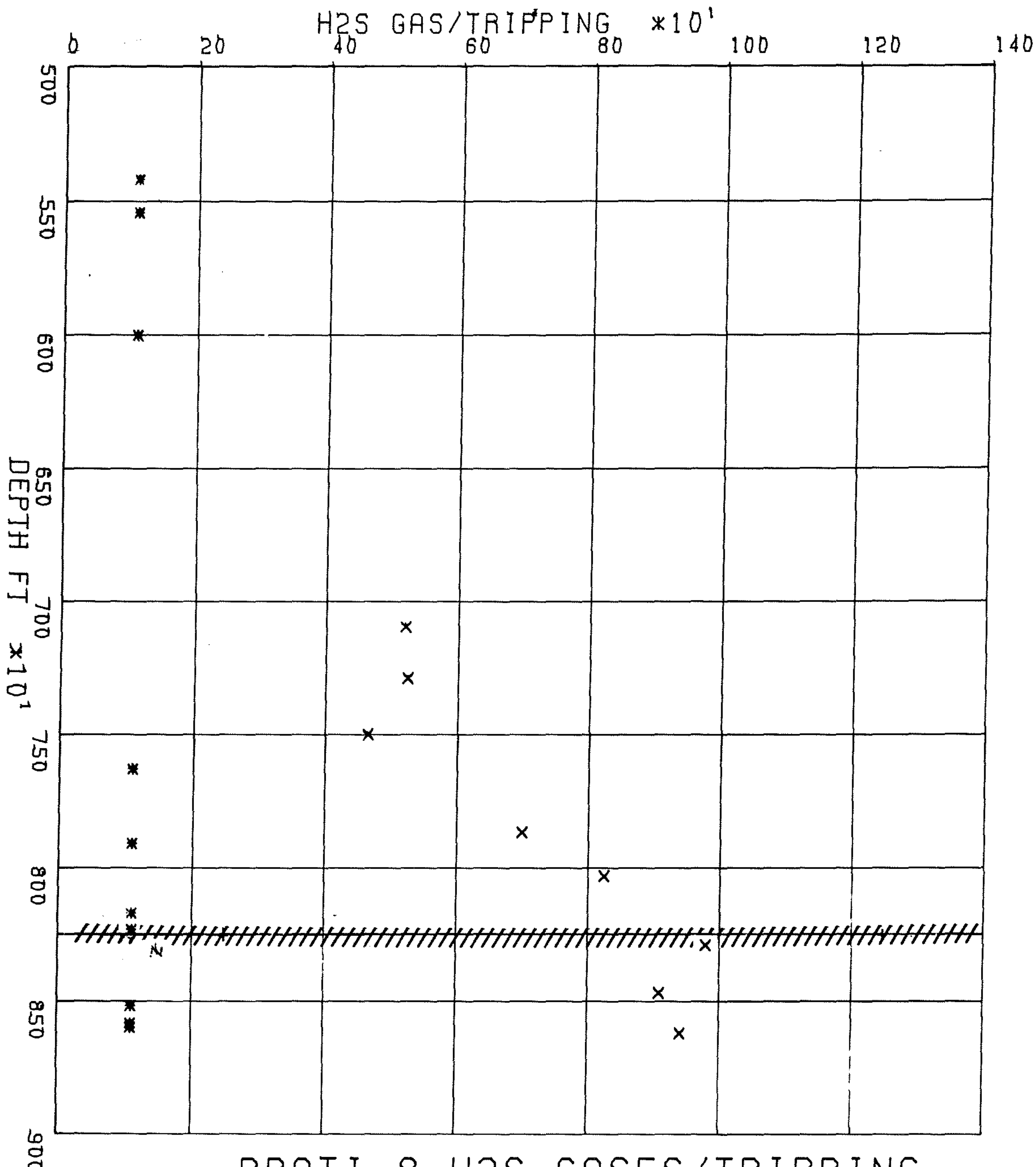


PRATI 5 CO2 GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

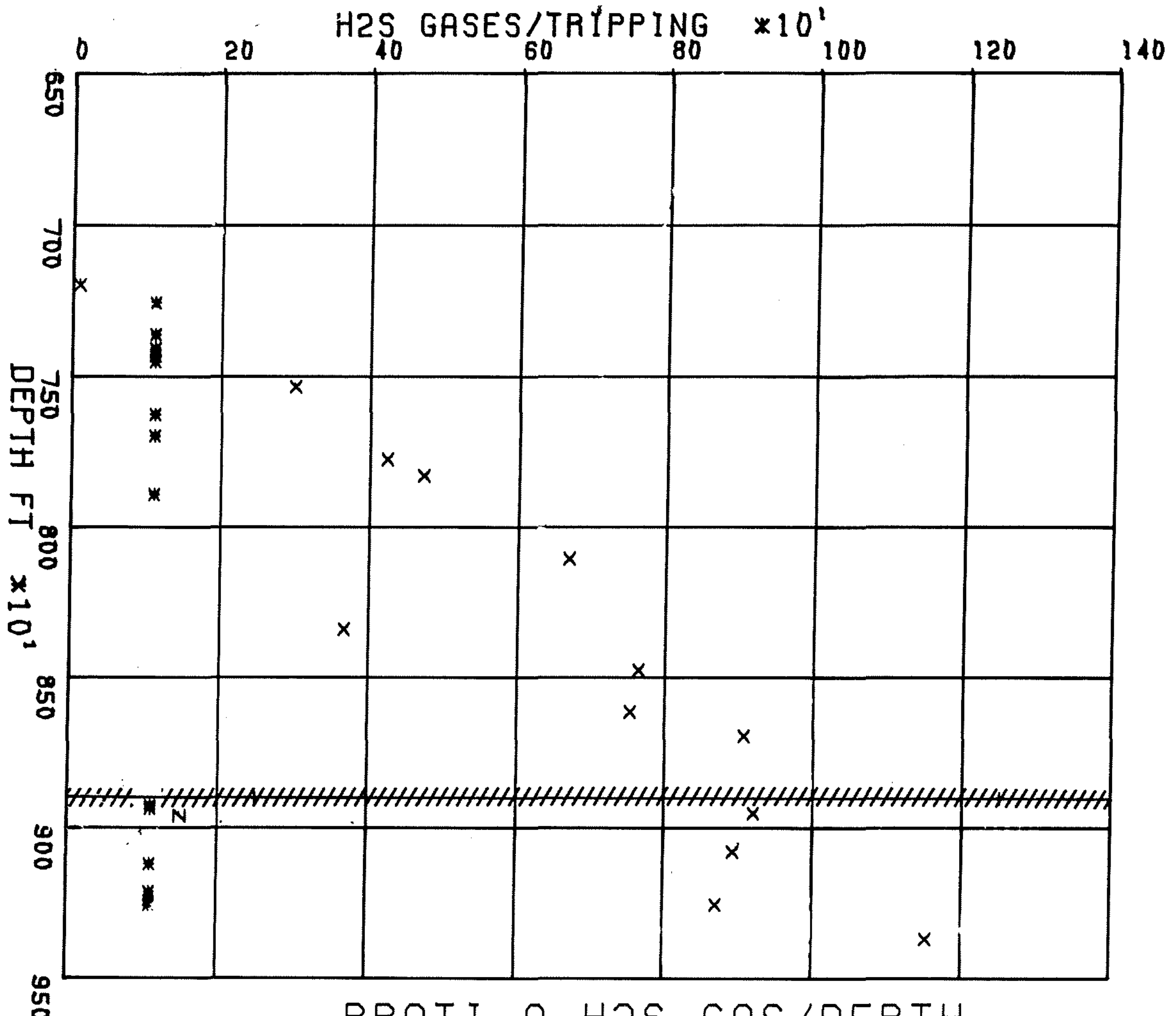
//////////////////// **- Est. Top of High Temperature Reservoir**



PRATI 8 H2S GASES/TRIPPING

X - H2S TRIP GAS
T - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

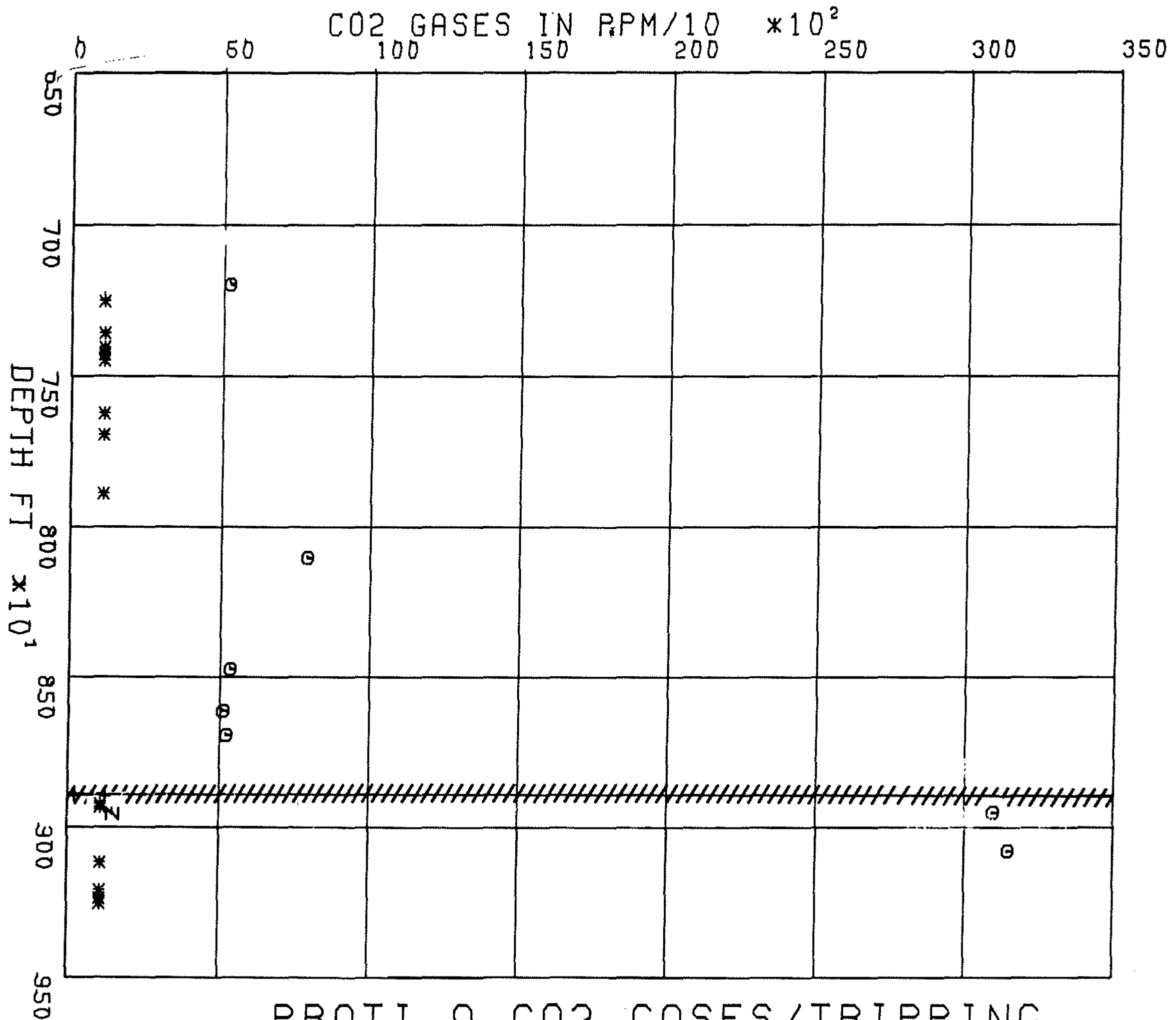
////////////////////// **- Est. Top of High Temperature Reservoir**



PRATI 9 H2S GAS/DEPTH

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

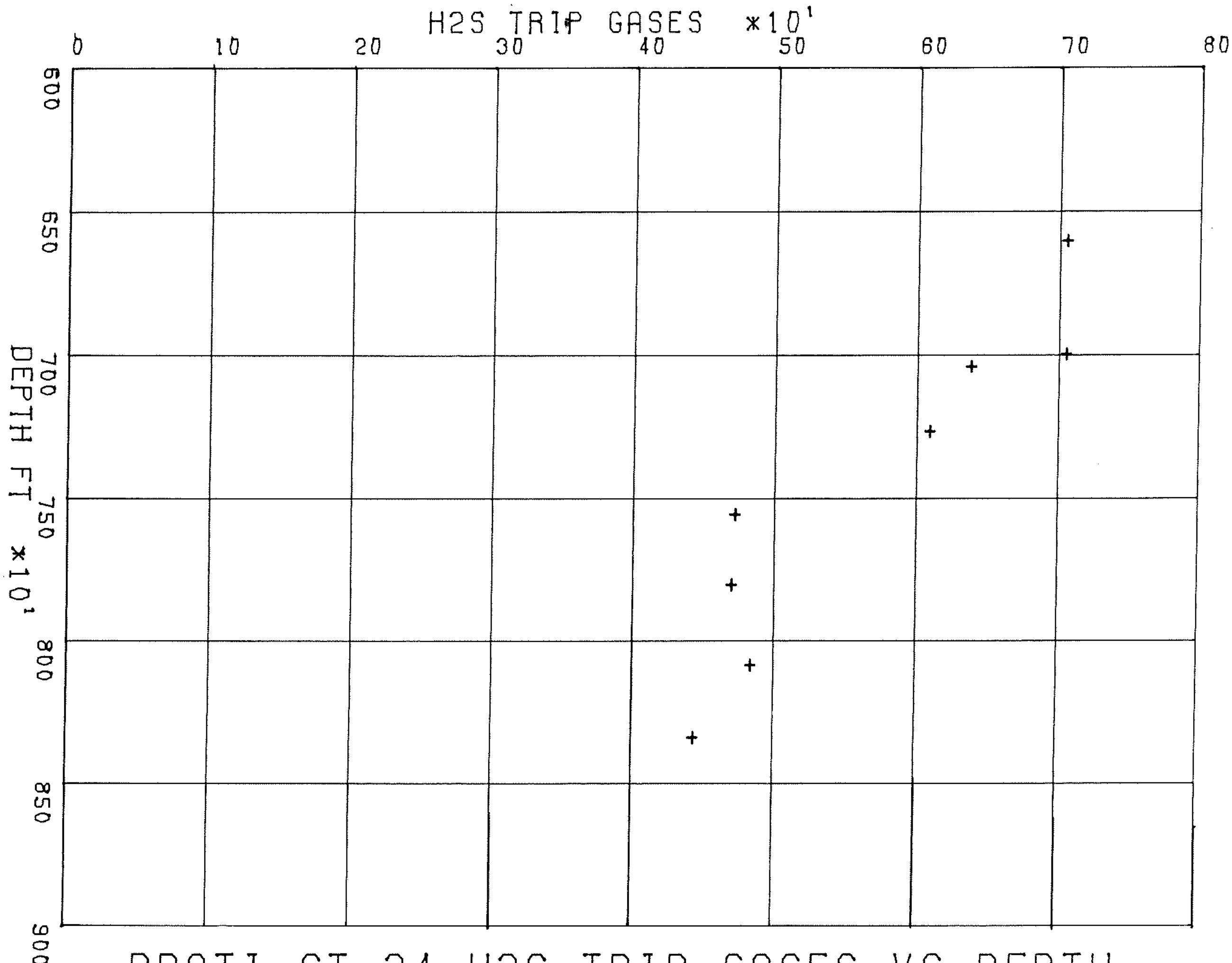
//////////////////// **- Est. Top of High Temperature Reservoir**



PRATI 9 CO2 GASES/TRIPPING

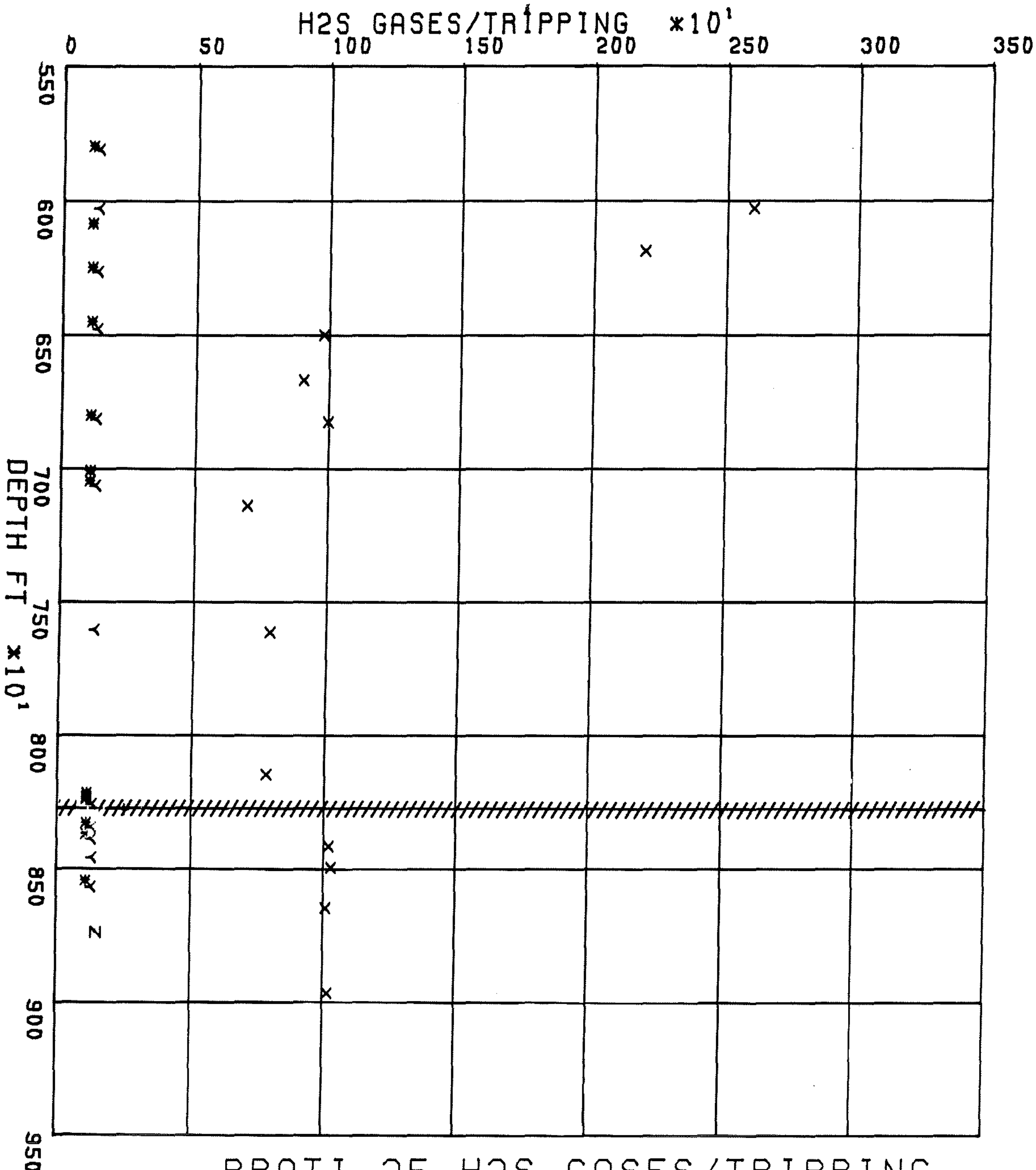
X - H2S TRIP GAS
† - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**



PRATI ST.24 H2S TRIP GASES VS DEPTH

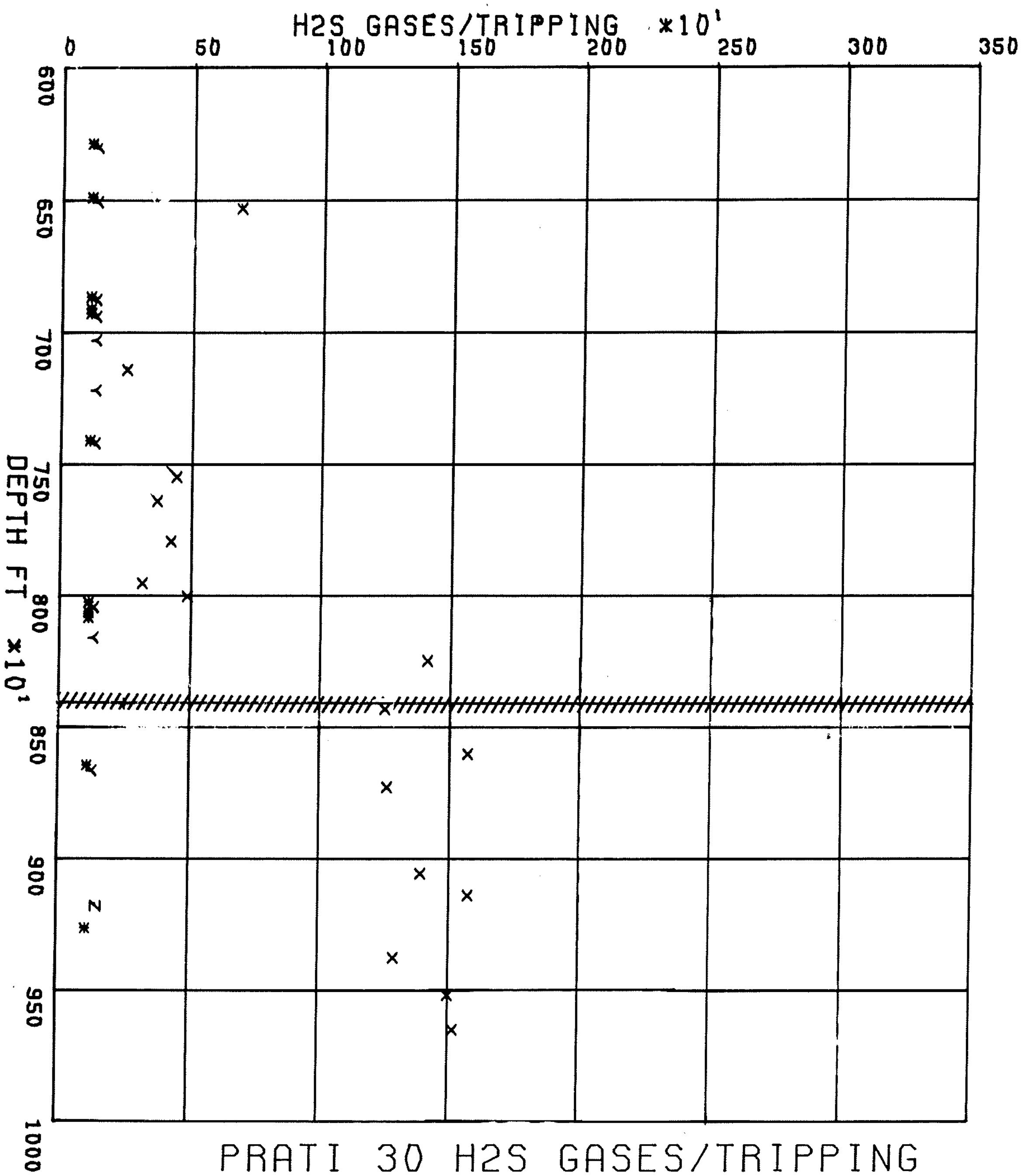
X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE



PRATI 25 H2S GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**

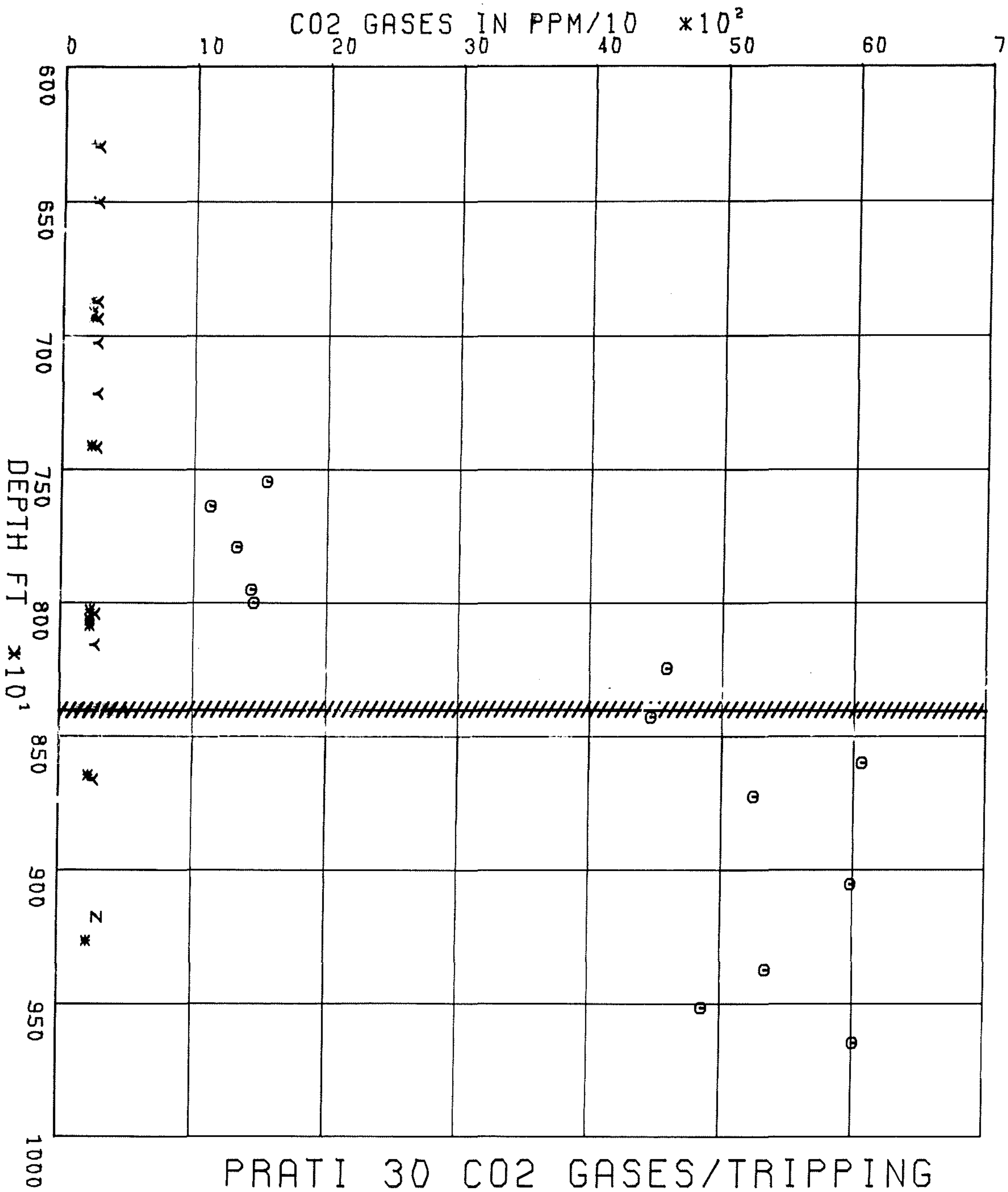


CONFIDENTIAL

PRATI 30 H2S GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

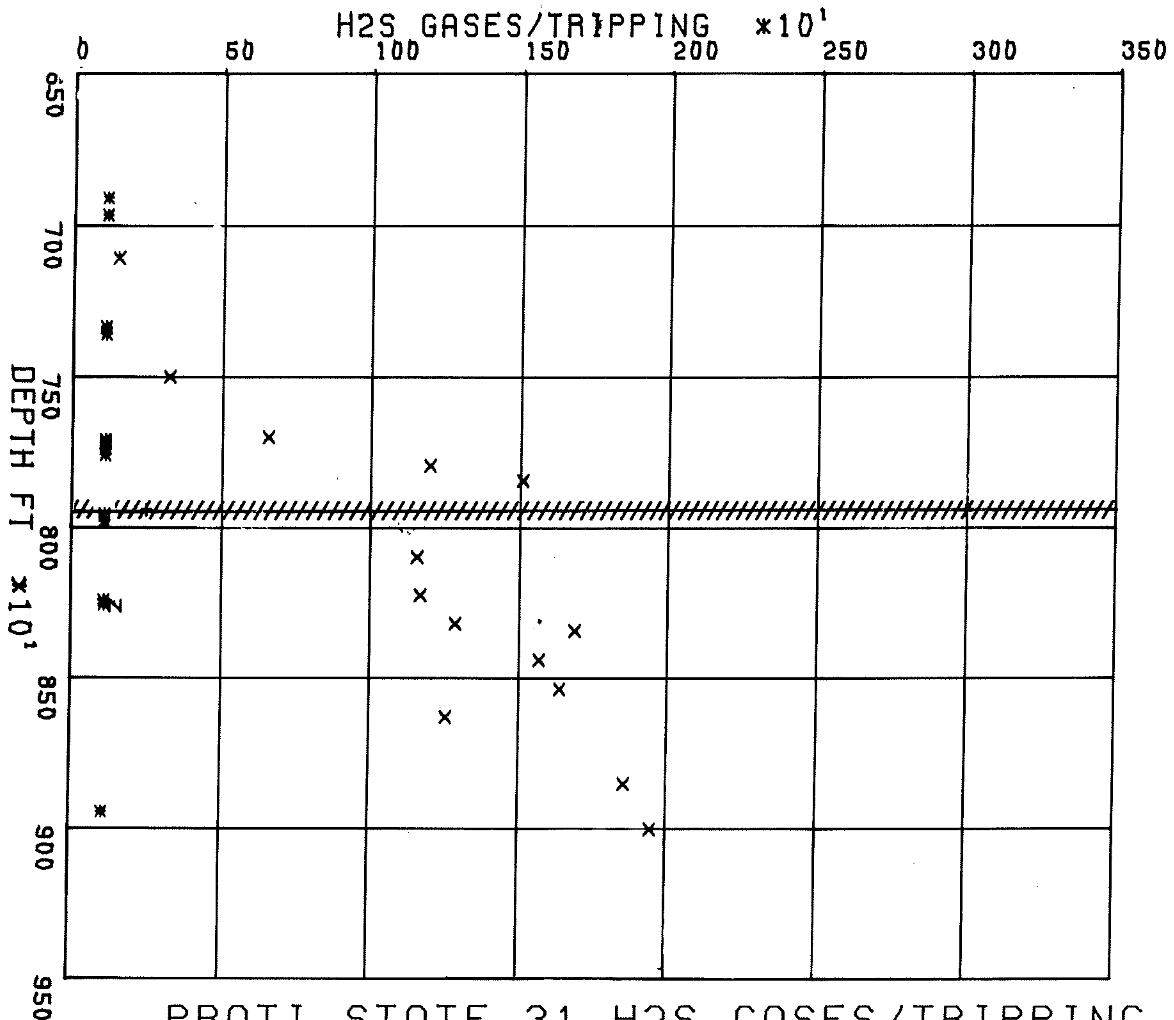
//////////////////// - **Est. Top of High Temperature Reservoir**



PRATI 30 CO2 GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**

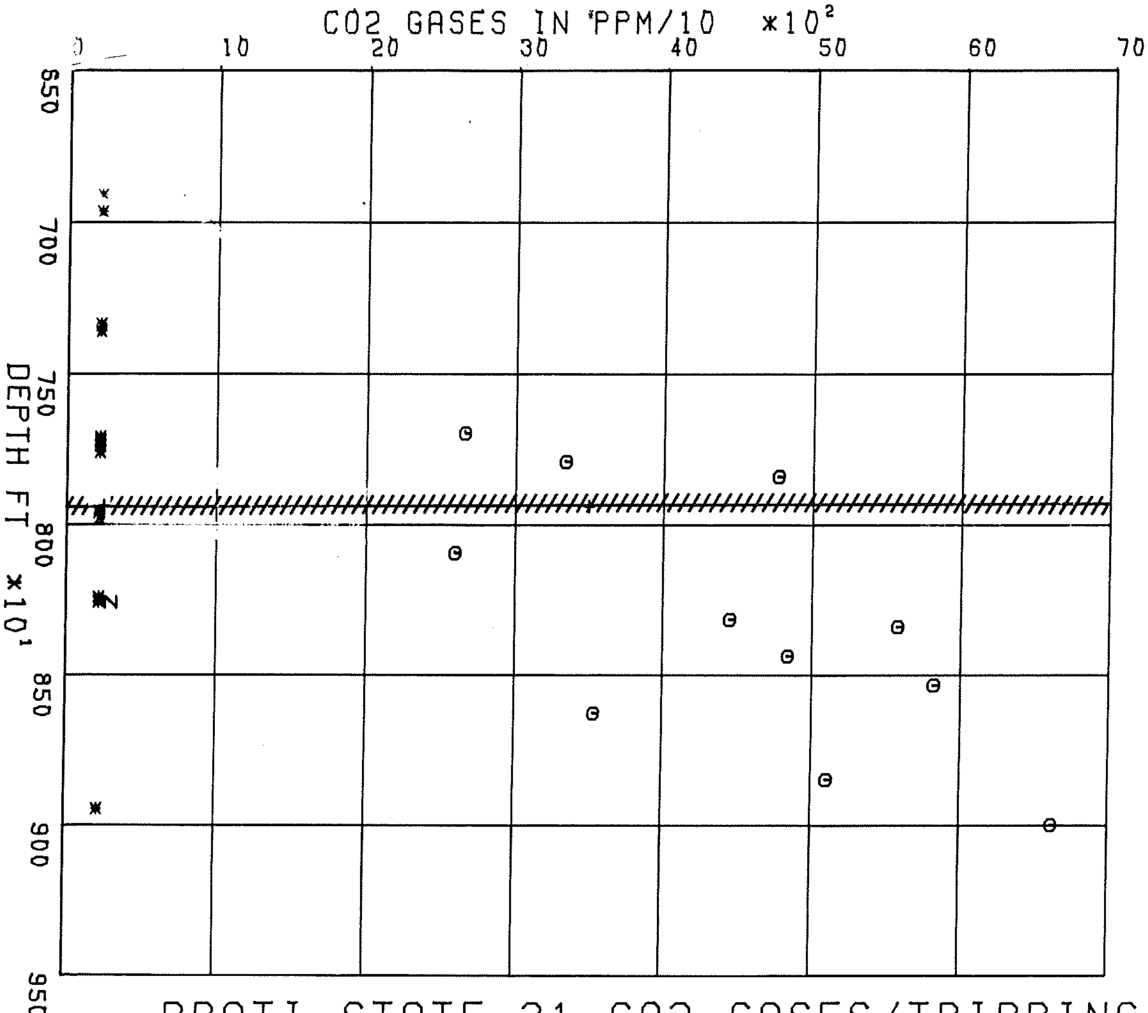


PRATI STATE 31 H2S GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**

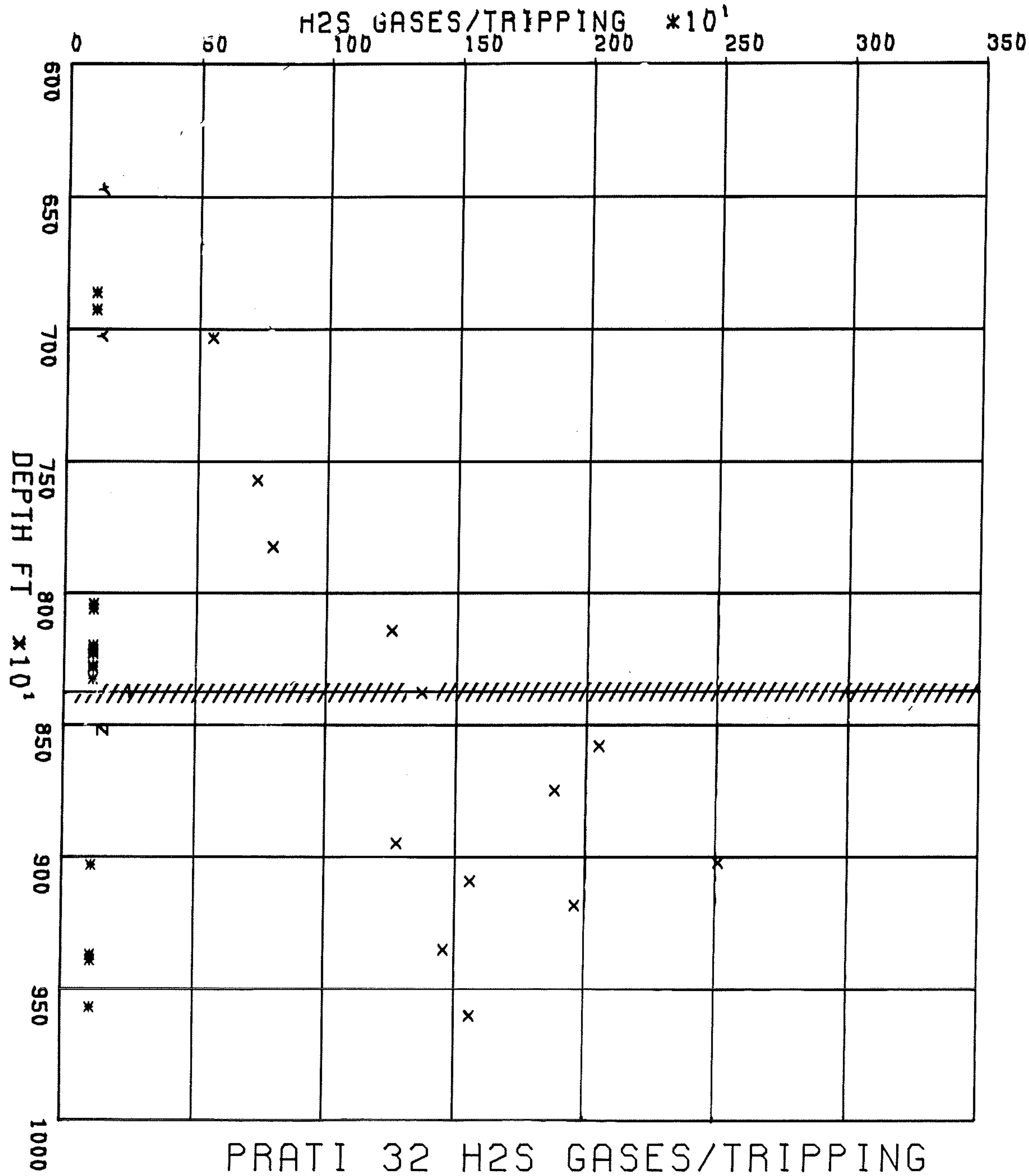
CONFIDENTIAL



PRATI STATE 31 CO2 GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

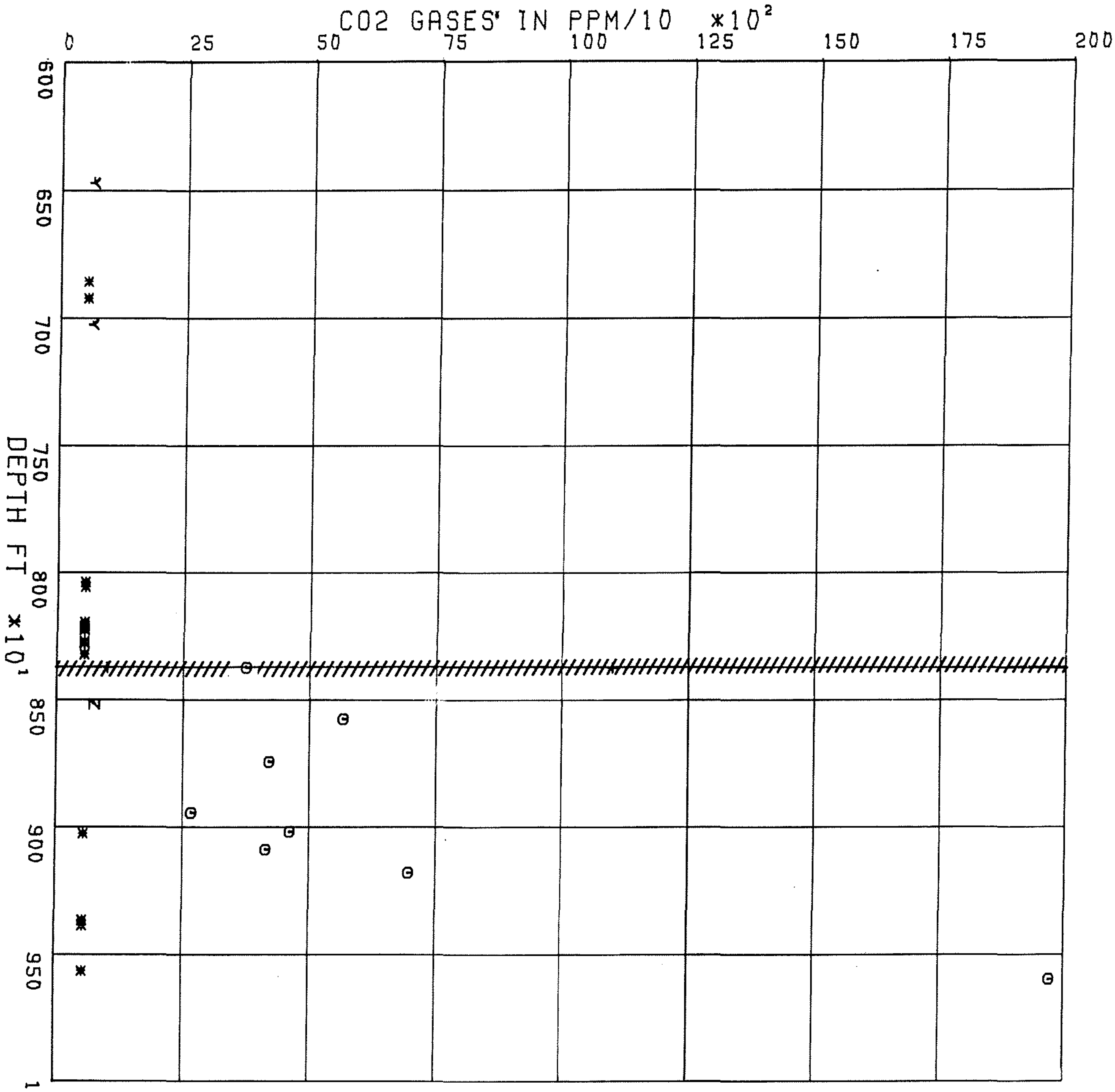
//////////////////// - **Est. Top of High Temperature Reservoir**



PRATI 32 H2S GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

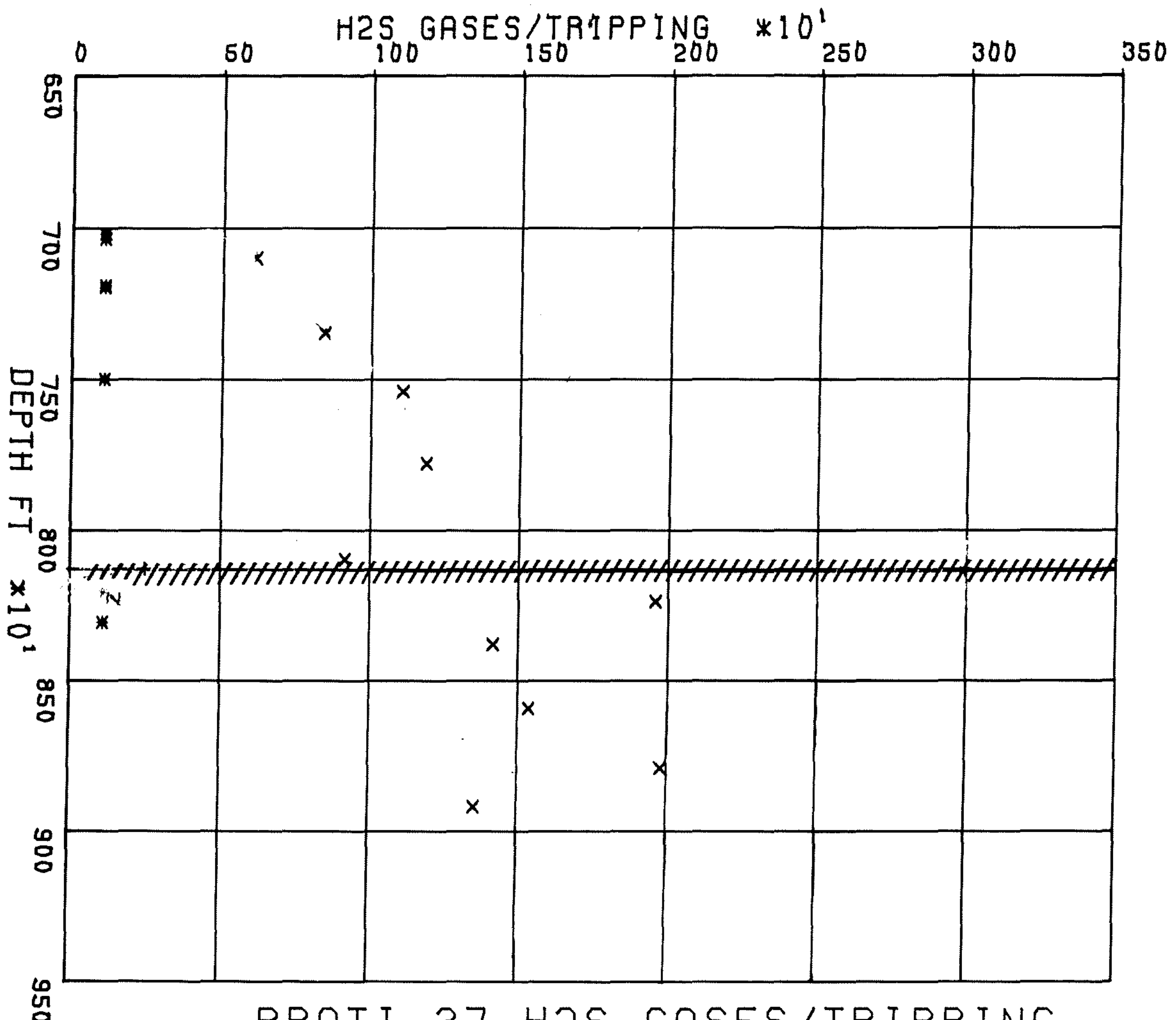
////////////////////// **- Est. Top of High Temperature Reservoir**



PRATI 32 CO2 GASES/TRIPPING

X - H2S TRIP GAS
ǂ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

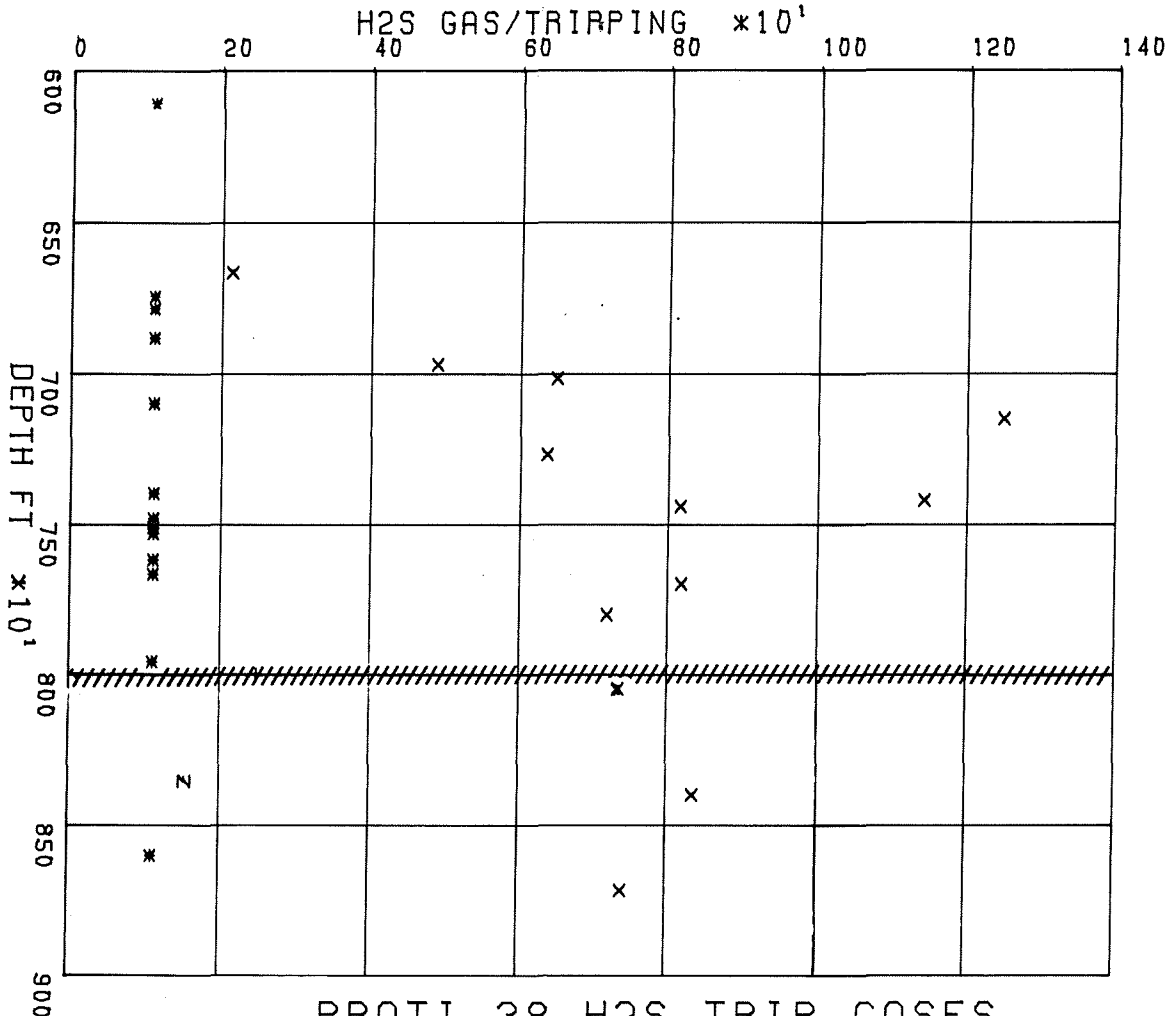
////////////////////// **- Est. Top of High Temperature Reservoir**



PRATI 37 H2S GASES/TRIPPING

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
0 - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

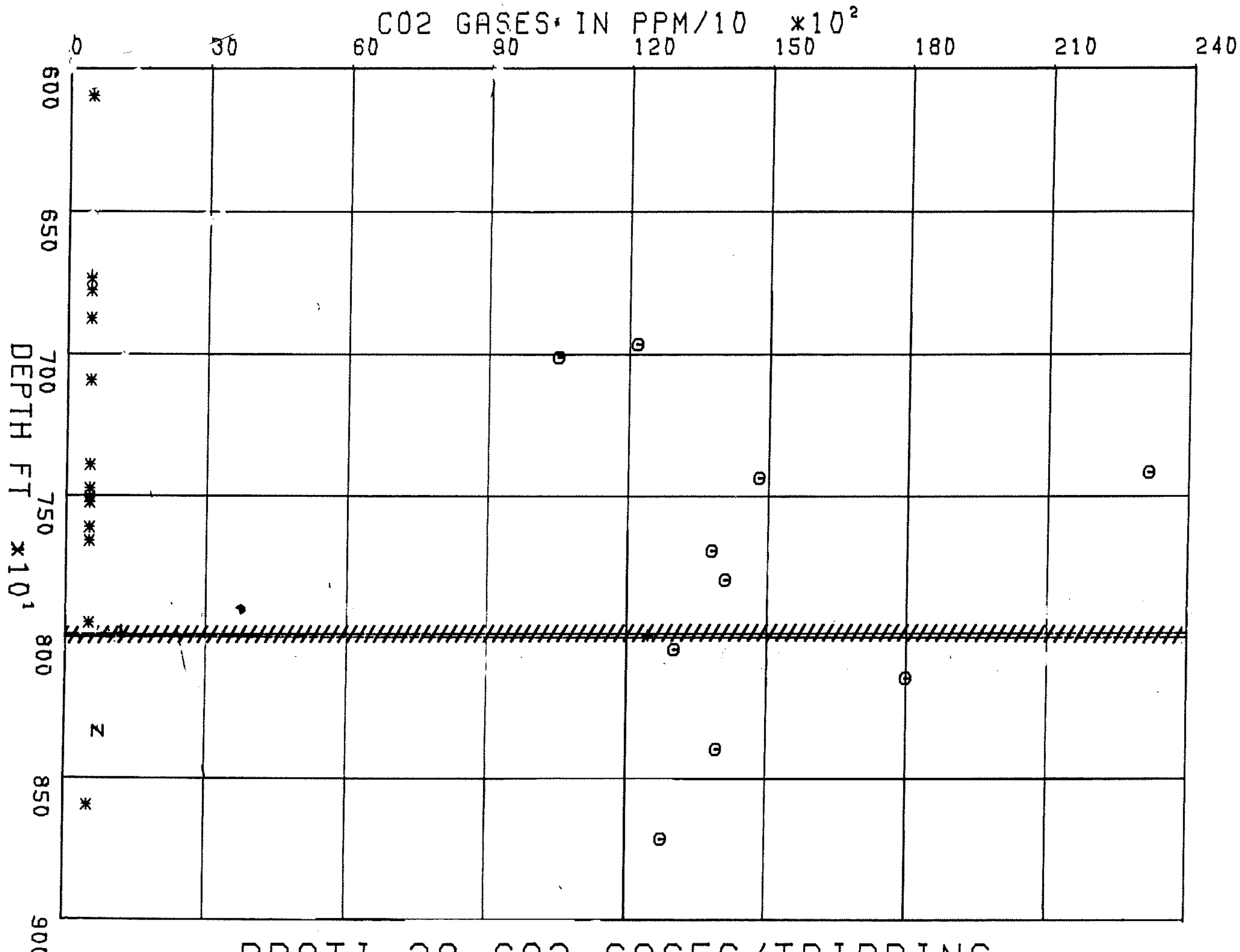
//////////////////// **- Est. Top of High Temperature Reservoir**



PRATI 38 H2S TRIP GASES

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**

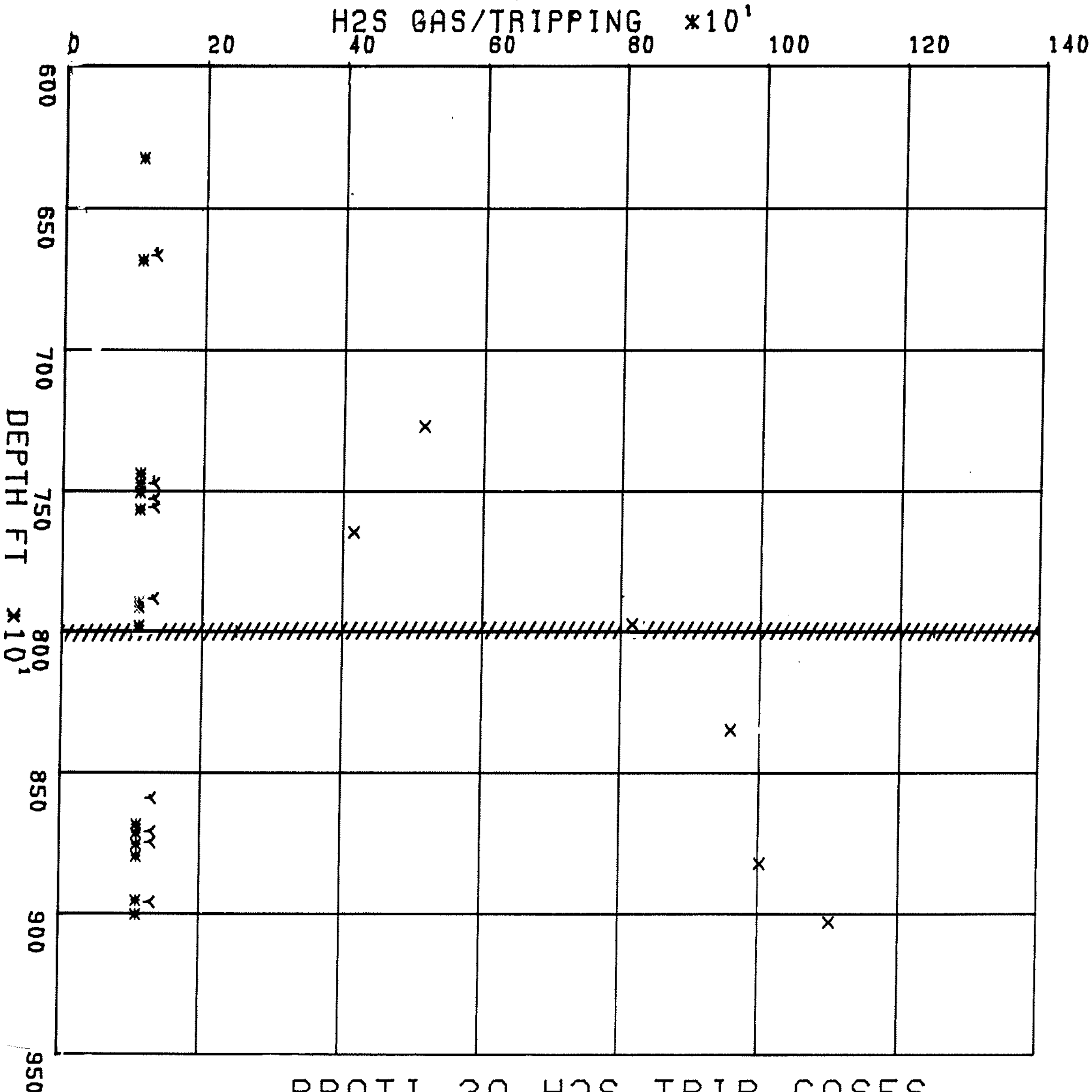


PRATI 38 CO2 GASES/TRIPPING

X - H2S TRIP GAS
† - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

//////////////////// **- Est. Top of High Temperature Reservoir**

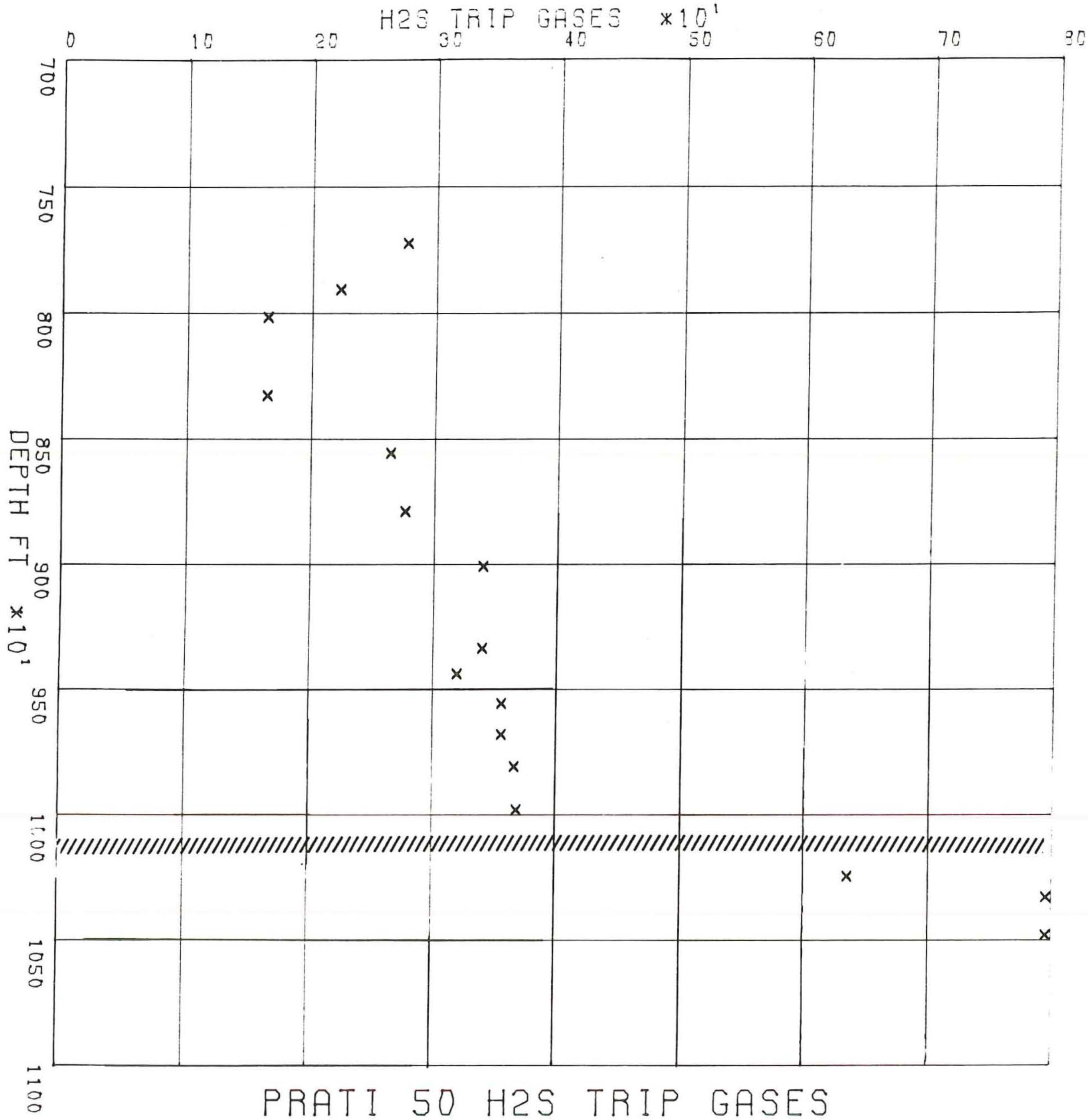
CONFIDENTIAL



PRATI 39 H2S TRIP GASES

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

///////////////////// **- Est. Top of High Temperature Reservoir**

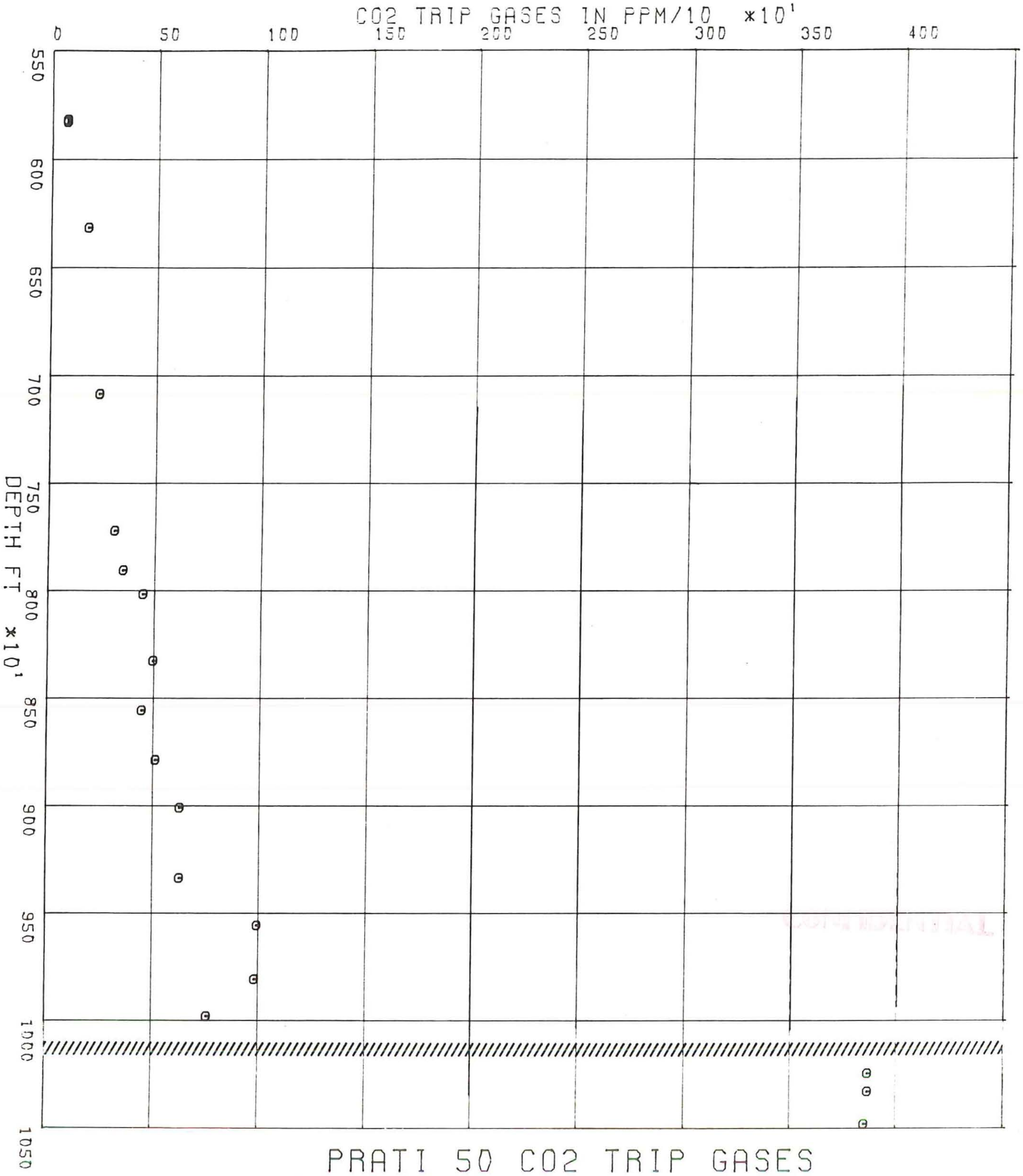


PRATI 50 H2S TRIP GASES

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
0 - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

////////////////////// **- Est. Top of High Temperature Reservoir**

CONFIDENTIAL



PRATI 50 CO2 TRIP GASES

X - H2S TRIP GAS
+ - TOP OF HI TEMP. RESERVOIR
O - CO2 TRIP GAS
* - STEAM ENTRY FROM MUD LOG
Y - STEAM ENTRY FROM ELECTRIC LOG
Z - TOP OF HORNFELSIC GRAYWACKE

//////////////////// **- Est. Top of High Temperature Reservoir**

APPENDIX VII

ENTHALPY CALCULATIONS FOR GEOOC WELLS IN AREAS A-1, A-2, 3

CONFIDENTIAL

Well Name pst-1

Z = 200.	F(t) = 0.70	U = 50.31	Q = 1.81	Ts = 335.00	Te = 60.00
= 118.	F(t) = 0.70	U = 50.31	Q = 1.04	Ts = 338.66	Te = 74.00
= 200.	F(t) = 1.02	U = 68.89	Q = 1.71	Ts = 340.77	Te = 82.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.64	Ts = 344.27	Te = 96.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.57	Ts = 347.63	Te = 110.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.50	Ts = 350.85	Te = 124.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.42	Ts = 353.96	Te = 138.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.35	Ts = 356.93	Te = 152.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.27	Ts = 359.77	Te = 166.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.19	Ts = 362.48	Te = 180.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.12	Ts = 365.04	Te = 194.26
Z = 200.	F(t) = 1.02	U = 68.89	Q = 1.04	Ts = 367.46	Te = 208.26
Z = 41.	F(t) = 1.02	U = 68.89	Q = 0.20	Ts = 369.75	Te = 222.26
Z = 200.	F(t) = 1.09	U = 68.89	Q = 0.83	Ts = 370.20	Te = 225.13
Z = 46.	F(t) = 1.09	U = 68.89	Q = 0.19	Ts = 374.51	Te = 239.13
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.86	Ts = 375.45	Te = 242.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.79	Ts = 379.51	Te = 256.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.72	Ts = 383.28	Te = 270.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.65	Ts = 386.76	Te = 284.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.58	Ts = 389.99	Te = 298.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.50	Ts = 392.97	Te = 312.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.43	Ts = 395.73	Te = 326.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.35	Ts = 398.27	Te = 340.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.27	Ts = 400.61	Te = 354.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.19	Ts = 402.74	Te = 368.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = 0.10	Ts = 404.69	Te = 382.35
= 200.	F(t) = 1.35	U = 106.70	Q = 0.02	Ts = 406.44	Te = 396.35
= 200.	F(t) = 1.35	U = 106.70	Q = -0.06	Ts = 408.02	Te = 410.35
Z = 200.	F(t) = 1.35	U = 106.70	Q = -0.15	Ts = 409.41	Te = 424.35
Z = 170.	F(t) = 1.35	U = 106.70	Q = -0.20	Ts = 410.63	Te = 438.35
Z = 200.	F(t) = 1.61	U = 0.00	Q = -0.41	Ts = 411.54	Te = 450.25
Z = 158.	F(t) = 1.61	U = 0.00	Q = -0.41	Ts = 412.36	Te = 464.25

pst-1 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.07 degrees F/ft
Time From Start of Flow = 14 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 335 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 112.2 psia
Steam Delivery = 130900 lbs/hr

Depth of First Steam Entry = 5933 feet

Casing # 1
Casing length (feet) = 318
Inside diameter (inches) = 12.515
Outside diameter (inches) = 20
Hole radius (inches) = 13
Earth Thermal Conductivity = 5.7 TCU
arth Diffusivity (alpha) = 0.92 sq.ft./day
ement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 2041
Inside diameter (inches) = 12.515
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75

Earth Thermal Conductivity = 5.7 TCU
Earth Diffusivity (alpha) = 0.92 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 246
Inside diameter (inches) = 8.835
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 2970
Inside diameter (inches) = 8.835
Outside diameter (inches) = 9.625
Hole radius (inches) = 6.125
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 358
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 4.375
Earth Thermal Conductivity = 6.27 TCU
Earth Diffusivity (alpha) = 1.04 sq.ft./day

**** pst-1 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1188.4382 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	114.92299	1191.28326	340.77200
2	131.44374	1205.28747	370.19810
3	141.98814	1206.30501	375.44504
4	234.58177	1211.35657	411.53662
5	243.76026	1210.53491	412.86533

Well Name prati-2

Z = 200.	F(t) = 1.34	U = 50.31	Q = 3.64	Ts = 365.00	Te = 60.00
= 114.	F(t) = 1.34	U = 50.31	Q = 2.03	Ts = 370.74	Te = 74.60
Z = 200.	F(t) = 1.71	U = 68.89	Q = 3.57	Ts = 373.98	Te = 82.92
Z = 200.	F(t) = 1.71	U = 68.89	Q = 3.46	Ts = 379.74	Te = 97.52
Z = 200.	F(t) = 1.71	U = 68.89	Q = 3.34	Ts = 385.39	Te = 112.12
Z = 200.	F(t) = 1.71	U = 68.89	Q = 3.23	Ts = 390.93	Te = 126.72
Z = 200.	F(t) = 1.71	U = 68.89	Q = 3.11	Ts = 396.35	Te = 141.32
Z = 200.	F(t) = 1.71	U = 68.89	Q = 3.00	Ts = 401.62	Te = 155.92
Z = 200.	F(t) = 1.71	U = 68.89	Q = 2.88	Ts = 406.74	Te = 170.52
Z = 200.	F(t) = 1.71	U = 68.89	Q = 2.76	Ts = 411.71	Te = 185.12
Z = 200.	F(t) = 1.71	U = 68.89	Q = 2.63	Ts = 416.50	Te = 199.72
Z = 200.	F(t) = 1.71	U = 68.89	Q = 2.51	Ts = 421.12	Te = 214.32
Z = 200.	F(t) = 1.71	U = 68.89	Q = 2.38	Ts = 425.55	Te = 228.92
Z = 200.	F(t) = 1.71	U = 68.89	Q = 2.25	Ts = 429.78	Te = 243.52
Z = 200.	F(t) = 1.71	U = 68.89	Q = 2.12	Ts = 433.80	Te = 258.12
Z = 28.	F(t) = 1.71	U = 68.89	Q = 0.29	Ts = 437.60	Te = 272.72
Z = 200.	F(t) = 1.83	U = 68.89	Q = 1.78	Ts = 438.12	Te = 274.77
Z = 72.	F(t) = 1.83	U = 68.89	Q = 0.61	Ts = 441.64	Te = 289.37
Z = 200.	F(t) = 2.18	U = 106.70	Q = 1.71	Ts = 442.86	Te = 294.62
Z = 200.	F(t) = 2.18	U = 106.70	Q = 1.58	Ts = 446.26	Te = 309.22
Z = 200.	F(t) = 2.18	U = 106.70	Q = 1.44	Ts = 449.42	Te = 323.82
Z = 200.	F(t) = 2.18	U = 106.70	Q = 1.29	Ts = 452.33	Te = 338.42
Z = 200.	F(t) = 2.18	U = 106.70	Q = 1.15	Ts = 454.98	Te = 353.02
Z = 200.	F(t) = 2.18	U = 106.70	Q = 1.00	Ts = 457.38	Te = 367.62
Z = 200.	F(t) = 2.18	U = 106.70	Q = 0.85	Ts = 459.50	Te = 382.22
Z = 200.	F(t) = 2.18	U = 106.70	Q = 0.69	Ts = 461.35	Te = 396.82
= 200.	F(t) = 2.18	U = 106.70	Q = 0.54	Ts = 462.91	Te = 411.42
= 200.	F(t) = 2.18	U = 106.70	Q = 0.37	Ts = 464.19	Te = 426.02
Z = 173.	F(t) = 2.18	U = 106.70	Q = 0.19	Ts = 465.18	Te = 440.62
Z = 200.	F(t) = 2.48	U = 0.00	Q = 0.08	Ts = 465.79	Te = 453.25
Z = 128.	F(t) = 2.48	U = 0.00	Q = -0.06	Ts = 466.26	Te = 467.85

prati-2 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.073 degrees F/ft
Time From Start of Flow = 81 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 365 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 162.75 psia
Steam Delivery = 54450 lbs/hr

Depth of First Steam Entry = 5715 feet

Casing # 1
Casing length (feet) = 314
Inside diameter (inches) = 12.515
Outside diameter (inches) = 20
Hole radius (inches) = 13
Earth Thermal Conductivity = 5.7 TCU
Earth Diffusivity (alpha) = 0.92 sq.ft./day
ement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 2628
Inside diameter (inches) = 12.515
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 6.05 TCU

Earth Diffusivity (alpha)	=	1.2 sq.ft./day
Cement thermal cond.	=	10.32 BTU/day degrees F/ft

Casing # 3

Casing length (feet)	=	272
Inside diameter (inches)	=	8.835
Outside diameter (inches)	=	13.375
Hole radius (inches)	=	8.75
Earth Thermal Conductivity	=	7 TCU
Earth Diffusivity (alpha)	=	1.2 sq.ft./day
Cement thermal cond.	=	10.32 BTU/day degrees F/ft

Casing # 4

Casing length (feet)	=	2173
Inside diameter (inches)	=	8.835
Outside diameter (inches)	=	9.625
Hole radius (inches)	=	6.125
Earth Thermal Conductivity	=	7 TCU
Earth Diffusivity (alpha)	=	1.2 sq.ft./day
Cement thermal cond.	=	10.32 BTU/day degrees F/ft

Casing # 5

Casing length (feet)	=	328
Inside diameter (inches)	=	Ø
Outside diameter (inches)	=	Ø
Hole radius (inches)	=	4.375
Earth Thermal Conductivity	=	7 TCU
Earth Diffusivity (alpha)	=	1.2 sq.ft./day

**** prati-2 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1195.4026 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	163.12570	1201.07581	373.97567
2	166.43206	1238.59206	438.12055
3	168.43117	1240.98060	442.85504
4	183.92418	1251.79821	465.78857
5	186.28302	1251.81755	466.35009

well Name prati-4

Z	F(t)	U	Q	Ts	Te
200.	0.65	71.83	2.13	384.00	60.20
81.	0.65	71.83	0.85	388.02	71.60
200.	0.83	62.46	1.71	389.64	75.32
200.	0.83	62.46	1.67	392.96	87.50
200.	0.83	62.46	1.62	396.21	99.50
200.	0.83	62.46	1.57	399.38	111.10
200.	0.83	62.46	1.53	402.47	122.70
200.	0.83	62.46	1.48	405.47	134.30
200.	0.83	62.46	1.43	408.40	145.90
200.	0.83	62.46	1.38	411.24	157.50
200.	0.83	62.46	1.33	413.99	169.10
74.	0.83	62.46	0.48	416.66	180.70
200.	0.83	62.46	1.04	417.63	184.99
18.	0.83	62.46	0.09	421.16	196.59
200.	1.03	42.47	0.72	421.47	197.63
200.	1.03	42.47	0.69	424.34	209.23
200.	1.03	42.47	0.66	427.09	220.83
200.	1.03	42.47	0.63	429.71	232.43
200.	1.03	42.47	0.60	432.21	244.03
200.	1.03	42.47	0.57	434.61	255.63
200.	1.03	42.47	0.54	436.90	267.23
200.	1.03	42.47	0.51	439.09	278.83
200.	1.03	42.47	0.48	441.18	290.43
200.	1.03	42.47	0.45	443.17	302.03
200.	1.03	42.47	0.41	445.08	313.63
72.	1.03	42.47	0.14	446.90	325.23
200.	1.26	0.00	0.93	447.53	329.41
200.	1.26	0.00	0.85	450.28	341.01
200.	1.26	0.00	0.78	452.88	352.61
200.	1.26	0.00	0.70	455.31	364.21
200.	1.26	0.00	0.63	457.59	375.81
200.	1.26	0.00	0.55	459.70	387.41
200.	1.26	0.00	0.47	461.66	399.01
200.	1.26	0.00	0.39	463.45	410.61
200.	1.26	0.00	0.31	465.09	422.21
200.	1.26	0.00	0.22	466.57	433.81
200.	1.26	0.00	0.14	467.90	445.41
200.	1.26	0.00	0.05	469.06	457.01
148.	1.26	0.00	-0.02	470.07	468.61

prati-4 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.058 degrees F/ft
Time From Start of Flow = 8 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 384 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 142.45 psia
Steam Delivery = 205300 lbs/hr

Depth of First Steam Entry = 7193 feet

asing # 1
Casing length (feet) = 281
Inside diameter (inches) = 15.124
Outside diameter (inches) = 22
Hole radius (inches) = 13
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 1874
Inside diameter (inches) = 15.124
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 218
Inside diameter (inches) = 10.88
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 2272
Inside diameter (inches) = 10.88
Outside diameter (inches) = 11.75
Hole radius (inches) = 7.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 4.728 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 2548
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 5.313
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** prati-4 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1211.3018 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	144.26351	1214.28474	389.63554
2	156.08792	1228.49183	417.63120
3	162.97102	1229.62318	421.47163
4	222.65315	1236.02351	447.52795
5	280.98503	1242.02004	470.71091

Well Name prati-5

Z	=	200.	F(t)	=	0.61	U =	71.83	Q	=	4.00	Ts	=	394.00	Te =	60.00
	=	80.	F(t)	=	0.61	U =	71.83	Q	=	1.59	Ts	=	401.08	Te =	72.00
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.46	Ts	=	403.92	Te =	76.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.39	Ts	=	410.14	Te =	88.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.33	Ts	=	416.29	Te =	100.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.27	Ts	=	422.38	Te =	112.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.20	Ts	=	428.38	Te =	124.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.14	Ts	=	434.31	Te =	136.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.07	Ts	=	440.15	Te =	148.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	3.00	Ts	=	445.89	Te =	160.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	2.94	Ts	=	451.54	Te =	172.80
Z	=	94.	F(t)	=	0.67	U =	62.46	Q	=	1.36	Ts	=	457.08	Te =	184.80
Z	=	200.	F(t)	=	0.67	U =	62.46	Q	=	2.23	Ts	=	459.66	Te =	190.44
Z	=	20.	F(t)	=	0.67	U =	62.46	Q	=	0.22	Ts	=	464.44	Te =	202.44
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.52	Ts	=	464.91	Te =	203.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.46	Ts	=	468.33	Te =	215.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.41	Ts	=	471.65	Te =	227.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.36	Ts	=	474.85	Te =	239.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.31	Ts	=	477.93	Te =	251.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.25	Ts	=	480.91	Te =	263.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.20	Ts	=	483.77	Te =	275.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.15	Ts	=	486.52	Te =	287.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.09	Ts	=	489.15	Te =	299.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	1.03	Ts	=	491.67	Te =	311.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.98	Ts	=	494.07	Te =	323.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.92	Ts	=	496.36	Te =	335.64
	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.86	Ts	=	498.53	Te =	347.64
	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.80	Ts	=	500.58	Te =	359.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.74	Ts	=	502.51	Te =	371.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.68	Ts	=	504.32	Te =	383.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.62	Ts	=	506.02	Te =	395.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.56	Ts	=	507.59	Te =	407.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.50	Ts	=	509.04	Te =	419.64
Z	=	200.	F(t)	=	0.90	U =	42.47	Q	=	0.43	Ts	=	510.36	Te =	431.64
Z	=	93.	F(t)	=	0.90	U =	42.47	Q	=	0.18	Ts	=	511.56	Te =	443.64
Z	=	200.	F(t)	=	1.13	U =	0.00	Q	=	0.91	Ts	=	512.08	Te =	449.22
Z	=	200.	F(t)	=	1.13	U =	0.00	Q	=	0.75	Ts	=	514.18	Te =	461.22
Z	=	48.	F(t)	=	1.13	U =	0.00	Q	=	0.16	Ts	=	515.97	Te =	473.22

prati-5 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient	=	0.06 degrees F/ft
Time From Start of Flow	=	5.75 hrs
Earth Temp. at Well Head	=	60 degrees F
Steam Temp. at Well Head	=	394 degrees F
Depth change (delta length)	=	200 feet
Well Head Pressure	=	140.45 psia
Steam Delivery	=	118200 lbs/hr
Depth of First Steam Entry	=	6935 feet

Casing # 1

Casing length (feet)	=	280
Inside diameter (inches)	=	15.624
Outside diameter (inches)	=	22
Hole radius (inches)	=	13
Earth Thermal Conductivity	=	7 TCU
Earth Diffusivity (alpha)	=	1.2 sq.ft./day
Cement thermal cond.	=	11 BTU/day degrees F/ft

```
Casing # 2
Casing  length    (feet)      =  1894
Inside  diameter (inches)   =  15.624
Outside diameter (inches)   =  16
Hole     radius    (inches)   =  10.25
Earth Thermal Conductivity =  7  TCU
 arth Diffusivity (alpha)   =  1.2  sq.ft./day
Cement thermal cond.          =  10.32  BTU/day degrees F/ft

Casing # 3
Casing  length    (feet)      =  220
Inside  diameter (inches)   =  10.772
Outside diameter (inches)   =  16
Hole     radius    (inches)   =  10.25
Earth Thermal Conductivity =  7  TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
Cement thermal cond.          =  10.32  BTU/day degrees F/ft

Casing # 4
Casing  length    (feet)      =  4093
Inside  diameter (inches)   =  10.772
Outside diameter (inches)   =  11.75
Hole     radius    (inches)   =  7.375
Earth Thermal Conductivity =  7  TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
Cement thermal cond.          =  4.728  BTU/day degrees F/ft

Casing # 5
Casing  length    (feet)      =  448
Inside  diameter (inches)   =  0
Outside diameter (inches)   =  0
 ole     radius    (inches)   =  5.313
 arth Thermal Conductivity =  7  TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
```

**** prati-5 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1217.5031 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	141.02240	1223.09378	403.92171
2	145.01603	1253.25787	459.65818
3	148.02900	1255.71186	464.90905
4	197.09287	1275.76072	512.08209
5	202.15483	1277.57277	516.36245

well Name prati-8

Z	F(t)	U	Q	Ts	Te
200.	0.62	50.31	4.19	345.00	60.00
119.	0.62	50.31	2.44	352.09	75.60
200.	0.89	68.89	4.45	356.29	84.88
200.	0.89	68.89	4.32	364.01	100.48
200.	0.89	68.89	4.18	371.60	116.08
200.	0.89	68.89	4.05	379.05	131.68
200.	0.89	68.89	3.90	386.33	147.28
200.	0.89	68.89	3.76	393.42	162.88
200.	0.89	68.89	3.61	400.32	178.48
200.	0.89	68.89	3.46	407.00	194.08
200.	0.89	68.89	3.31	413.44	209.68
200.	0.89	68.89	3.15	419.65	225.28
200.	0.89	68.89	2.99	425.59	240.88
45.	0.89	68.89	0.66	431.25	256.48
200.	0.89	68.89	2.26	432.50	259.99
12.	0.89	68.89	0.13	437.35	275.59
200.	1.13	106.70	2.41	437.63	276.53
200.	1.13	106.70	2.25	442.75	292.13
200.	1.13	106.70	2.08	447.55	307.73
200.	1.13	106.70	1.90	452.01	323.33
200.	1.13	106.70	1.72	456.13	338.93
200.	1.13	106.70	1.53	459.89	354.53
200.	1.13	106.70	1.34	463.30	370.13
200.	1.13	106.70	1.14	466.33	385.73
200.	1.13	106.70	0.94	468.98	401.33
200.	1.13	106.70	0.73	471.23	416.93
200.	1.13	106.70	0.52	473.08	432.53
200.	1.13	106.70	0.29	474.52	448.13
119.	1.13	106.70	0.07	475.53	463.73
123.	1.38	0.00	-0.03	475.92	473.01

prati-8 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.078 degrees F/ft
Time From Start of Flow = 7.75 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 345 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 119.3 psia
Steam Delivery = 62376 lbs/hr

Depth of First Steam Entry = 5418 feet

Casing # 1
Casing length (feet) = 319
Inside diameter (inches) = 12.515
Outside diameter (inches) = 20
Hole radius (inches) = 13
Earth Thermal Conductivity = 6.14 TCU
Earth Diffusivity (alpha) = 1.01 sq.ft./day
Cement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 2245
Inside diameter (inches) = 12.515
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 212
Inside diameter (inches) = 8.835
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 2519
Inside diameter (inches) = 8.835
Outside diameter (inches) = 9.625
Hole radius (inches) = 6.125
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 123
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 4.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** prati-8 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1192.8135 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	119.96432	1199.44374	356.29301
2	124.85709	1241.28919	432.50118
3	127.54761	1243.67694	437.63310
4	156.76240	1260.59874	475.92303
5	158.12968	1260.57010	476.16252

Well Name prati-9

Z =	200.	F(t) =	1.48	U =	50.31	Q =	3.30	Ts =	358.00	Te =	60.00
=	108.	F(t) =	1.48	U =	50.31	Q =	1.76	Ts =	363.35	Te =	71.60
Z =	200.	F(t) =	1.96	U =	68.89	Q =	3.28	Ts =	366.21	Te =	77.86
Z =	200.	F(t) =	1.96	U =	68.89	Q =	3.21	Ts =	371.64	Te =	89.46
Z =	200.	F(t) =	1.96	U =	68.89	Q =	3.14	Ts =	377.00	Te =	101.06
Z =	200.	F(t) =	1.96	U =	68.89	Q =	3.07	Ts =	382.30	Te =	112.66
Z =	200.	F(t) =	1.96	U =	68.89	Q =	2.99	Ts =	387.54	Te =	124.26
Z =	200.	F(t) =	1.96	U =	68.89	Q =	2.92	Ts =	392.69	Te =	135.86
Z =	200.	F(t) =	1.96	U =	68.89	Q =	2.84	Ts =	397.76	Te =	147.46
Z =	200.	F(t) =	1.96	U =	68.89	Q =	2.76	Ts =	402.74	Te =	159.06
Z =	200.	F(t) =	1.96	U =	68.89	Q =	2.69	Ts =	407.62	Te =	170.66
Z =	200.	F(t) =	1.96	U =	68.89	Q =	2.61	Ts =	412.40	Te =	182.26
Z =	119.	F(t) =	1.96	U =	68.89	Q =	1.52	Ts =	417.06	Te =	193.86
Z =	200.	F(t) =	1.96	U =	68.89	Q =	2.15	Ts =	419.80	Te =	200.77
Z =	11.	F(t) =	1.96	U =	68.89	Q =	0.12	Ts =	424.10	Te =	212.37
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.65	Ts =	424.33	Te =	213.00
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.59	Ts =	427.76	Te =	224.60
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.52	Ts =	431.06	Te =	236.20
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.45	Ts =	434.23	Te =	247.80
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.39	Ts =	437.28	Te =	259.40
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.32	Ts =	440.20	Te =	271.00
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.24	Ts =	442.98	Te =	282.60
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.17	Ts =	445.64	Te =	294.20
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.10	Ts =	448.16	Te =	305.80
Z =	200.	F(t) =	2.18	U =	48.30	Q =	1.03	Ts =	450.54	Te =	317.40
Z =	200.	F(t) =	2.18	U =	48.30	Q =	0.95	Ts =	452.78	Te =	329.00
=	200.	F(t) =	2.18	U =	48.30	Q =	0.87	Ts =	454.89	Te =	340.60
=	125.	F(t) =	2.18	U =	48.30	Q =	0.51	Ts =	456.85	Te =	352.20
Z =	200.	F(t) =	2.65	U =	0.00	Q =	1.26	Ts =	458.00	Te =	359.45
Z =	200.	F(t) =	2.65	U =	0.00	Q =	1.14	Ts =	460.66	Te =	371.05
Z =	200.	F(t) =	2.65	U =	0.00	Q =	1.01	Ts =	463.10	Te =	382.65
Z =	200.	F(t) =	2.65	U =	0.00	Q =	0.89	Ts =	465.31	Te =	394.25
Z =	200.	F(t) =	2.65	U =	0.00	Q =	0.75	Ts =	467.28	Te =	405.85
Z =	200.	F(t) =	2.65	U =	0.00	Q =	0.62	Ts =	469.01	Te =	417.45
Z =	200.	F(t) =	2.65	U =	0.00	Q =	0.48	Ts =	470.50	Te =	429.05
Z =	200.	F(t) =	2.65	U =	0.00	Q =	0.34	Ts =	471.74	Te =	440.65
Z =	200.	F(t) =	2.65	U =	0.00	Q =	0.20	Ts =	472.71	Te =	452.25
Z =	200.	F(t) =	2.65	U =	0.00	Q =	0.05	Ts =	473.43	Te =	463.85
Z =	92.	F(t) =	2.65	U =	0.00	Q =	-0.03	Ts =	473.88	Te =	475.45

prati-9 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient	=	0.058 degrees F/ft
Time From Start of Flow	=	96 hrs
Earth Temp. at Well Head	=	60 degrees F
Steam Temp. at Well Head	=	358 degrees F
Depth change (delta length)	=	200 feet
Well Head Pressure	=	147.5 psia
Steam Delivery	=	59200 lbs/hr

Depth of First Steam Entry = 7255 feet

Casing # 1

Casing length (feet)	=	308
Inside diameter (inches)	=	12.515
Outside diameter (inches)	=	20
Hole radius (inches)	=	13
Earth Thermal Conductivity	=	6.35 TCU
Earth Diffusivity (alpha)	=	1.06 sq.ft./day

Cement thermal cond.	= 11 BTU/day degrees F/ft

Casing # 2

Casing length (feet)	= 2119
Inside diameter (inches)	= 12.515
Outside diameter (inches)	= 13.375
Hole radius (inches)	= 8.75
Earth Thermal Conductivity	= 7 TCU
Earth Diffusivity (alpha)	= 1.2 sq.ft./day
Cement thermal cond.	= 10.32 BTU/day degrees F/ft

Casing # 3

Casing length (feet)	= 211
Inside diameter (inches)	= 8.835
Outside diameter (inches)	= 13.375
Hole radius (inches)	= 8.75
Earth Thermal Conductivity	= 7 TCU
Earth Diffusivity (alpha)	= 1.2 sq.ft./day
Cement thermal cond.	= 10.32 BTU/day degrees F/ft

Casing # 4

Casing length (feet)	= 2525
Inside diameter (inches)	= 8.835
Outside diameter (inches)	= 10.75
Hole radius (inches)	= 6.688
Earth Thermal Conductivity	= 7 TCU
Earth Diffusivity (alpha)	= 1.2 sq.ft./day
Cement thermal cond.	= 4.728 BTU/day degrees F/ft

Casing # 5

Casing length (feet)	= 2092
Inside diameter (inches)	= 0
Outside diameter (inches)	= 0
Hole radius (inches)	= 4.375
Earth Thermal Conductivity	= 7 TCU
Earth Diffusivity (alpha)	= 1.2 sq.ft./day

**** prati-9 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1194.3693 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	147.97296	1199.43445	366.21486
2	151.34822	1230.45711	419.79682
3	153.30077	1232.72438	424.33460
4	175.50271	1248.52026	458.00090
5	193.19751	1255.24046	473.99032

Well Name pst-10

Z =	200.	F(t) =	0.82	U =	47.20	Q =	2.18	Ts =	362.00	Te =	60.00
=	113.	F(t) =	0.82	U =	47.20	Q =	1.20	Ts =	366.88	Te =	77.20
Z =	200.	F(t) =	0.97	U =	68.89	Q =	2.37	Ts =	369.56	Te =	86.92
Z =	200.	F(t) =	0.97	U =	68.89	Q =	2.26	Ts =	374.70	Te =	104.12
Z =	200.	F(t) =	0.97	U =	68.89	Q =	2.16	Ts =	379.62	Te =	121.32
Z =	200.	F(t) =	0.97	U =	68.89	Q =	2.05	Ts =	384.33	Te =	138.52
Z =	200.	F(t) =	0.97	U =	68.89	Q =	1.94	Ts =	388.82	Te =	155.72
Z =	200.	F(t) =	0.97	U =	68.89	Q =	1.83	Ts =	393.10	Te =	172.92
Z =	200.	F(t) =	0.97	U =	68.89	Q =	1.71	Ts =	397.15	Te =	190.12
Z =	200.	F(t) =	0.97	U =	68.89	Q =	1.60	Ts =	400.98	Te =	207.32
Z =	200.	F(t) =	0.97	U =	68.89	Q =	1.48	Ts =	404.58	Te =	224.52
Z =	200.	F(t) =	0.97	U =	68.89	Q =	1.36	Ts =	407.96	Te =	241.72
Z =	200.	F(t) =	0.97	U =	68.89	Q =	1.24	Ts =	411.11	Te =	258.92
Z =	79.	F(t) =	0.97	U =	68.89	Q =	0.46	Ts =	414.02	Te =	276.12
Z =	200.	F(t) =	0.96	U =	46.73	Q =	0.76	Ts =	415.11	Te =	282.91
Z =	14.	F(t) =	0.96	U =	46.73	Q =	0.05	Ts =	417.77	Te =	300.11
Z =	200.	F(t) =	1.24	U =	48.89	Q =	0.63	Ts =	417.95	Te =	301.32
Z =	200.	F(t) =	1.24	U =	48.89	Q =	0.55	Ts =	420.33	Te =	318.52
Z =	200.	F(t) =	1.24	U =	48.89	Q =	0.46	Ts =	422.51	Te =	335.72
Z =	200.	F(t) =	1.24	U =	48.89	Q =	0.37	Ts =	424.49	Te =	352.92
Z =	200.	F(t) =	1.24	U =	48.89	Q =	0.28	Ts =	426.28	Te =	370.12
Z =	200.	F(t) =	1.24	U =	48.89	Q =	0.19	Ts =	427.88	Te =	387.32
Z =	200.	F(t) =	1.24	U =	48.89	Q =	0.09	Ts =	429.29	Te =	404.52
Z =	17.	F(t) =	1.24	U =	48.89	Q =	0.00	Ts =	430.51	Te =	421.72
Z =	200.	F(t) =	1.50	U =	0.00	Q =	-0.02	Ts =	430.61	Te =	423.18
Z =	200.	F(t) =	1.50	U =	0.00	Q =	-0.24	Ts =	431.67	Te =	440.38
=	177.	F(t) =	1.50	U =	0.00	Q =	-0.40	Ts =	432.34	Te =	457.58

pst-10 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.086 degrees F/ft
Time From Start of Flow = 10 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 362 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 121.45 psia
Steam Delivery = 103900 lbs/hr

Deoth of First Steam Entry = 4800 feet

Casing # 1
Casing length (feet) = 313
Inside diameter (inches) = 9.95
Outside diameter (inches) = 20
Hole radius (inches) = 13
Earth Thermal Conductivity = 8.5 TCU
Earth Diffusivity (alpha) = 1.5 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 2279
nside diameter (inches) = 9.95
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7.15 TCU
Earth Diffusivity (alpha) = 1.23 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3

Casing length (feet) = [illegible]
Inside diameter (inches) = 8.835
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 7 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 1417
Inside diameter (inches) = 8.835
Outside diameter (inches) = 9.625
Hole radius (inches) = 6.125
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 4.728 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 577
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 4.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** pst-10 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1202.4905 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	126.67510	1205.86908	369.56168
2	160.64929	1226.32367	415.11491
3	165.86818	1227.13588	417.95115
4	197.06584	1229.70757	430.60882
5	208.98124	1229.05841	432.59831

Well Name p-24st-1

Z =	141.	F(t) =	0.60	U =	51.60	Q =	1.50	Ts =	387.00	Te =	60.00
Z =	200.	F(t) =	0.64	U =	47.20	Q =	1.73	Ts =	390.12	Te =	69.87
Z =	200.	F(t) =	0.64	U =	47.20	Q =	1.67	Ts =	393.84	Te =	83.87
Z =	200.	F(t) =	0.64	U =	47.20	Q =	1.61	Ts =	397.45	Te =	97.87
Z =	200.	F(t) =	0.64	U =	47.20	Q =	1.56	Ts =	400.94	Te =	111.87
Z =	17.	F(t) =	0.64	U =	47.20	Q =	0.13	Ts =	404.32	Te =	125.87
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.76	Ts =	404.60	Te =	127.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.70	Ts =	408.32	Te =	141.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.63	Ts =	411.92	Te =	155.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.56	Ts =	415.39	Te =	169.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.49	Ts =	418.72	Te =	183.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.42	Ts =	421.92	Te =	197.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.35	Ts =	424.98	Te =	211.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.28	Ts =	427.91	Te =	225.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.20	Ts =	430.70	Te =	239.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.13	Ts =	433.35	Te =	253.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	1.05	Ts =	435.86	Te =	267.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	0.98	Ts =	438.23	Te =	281.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	0.90	Ts =	440.46	Te =	295.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	0.82	Ts =	442.54	Te =	309.06
Z =	200.	F(t) =	0.90	U =	68.89	Q =	0.75	Ts =	444.47	Te =	323.06
Z =	5.	F(t) =	0.90	U =	68.89	Q =	0.02	Ts =	446.25	Te =	337.06
Z =	200.	F(t) =	1.15	U =	0.00	Q =	1.17	Ts =	446.30	Te =	337.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	1.04	Ts =	448.89	Te =	351.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	0.91	Ts =	451.24	Te =	365.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	0.77	Ts =	453.34	Te =	379.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	0.63	Ts =	455.18	Te =	393.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	0.49	Ts =	456.78	Te =	407.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	0.34	Ts =	458.10	Te =	421.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	0.19	Ts =	459.17	Te =	435.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	0.04	Ts =	459.96	Te =	449.41
Z =	200.	F(t) =	1.15	U =	0.00	Q =	-0.11	Ts =	460.48	Te =	463.41
Z =	107.	F(t) =	1.15	U =	0.00	Q =	-0.13	Ts =	460.71	Te =	477.41

p-24st-1 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.07 degrees F/ft
Time From Start of Flow = 8 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 387 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 131.35 psia
Steam Delivery = 161000 lbs/hr

Depth of First Steam Entry = 6070 feet

Casing # 1
Casing length (feet) = 141
Inside diameter (inches) = 12.515
Outside diameter (inches) = 30
Hole radius (inches) = 18
Earth Thermal Conductivity = 8.5 TCU
Earth Diffusivity (alpha) = 1.5 sq.ft./day
Cement thermal cond. = 11.76 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 817
Inside diameter (inches) = 12.515
Outside diameter (inches) = 20

```
Hole      radius     (inches)   =  13
Earth Thermal Conductivity =  3.59  TCU
Earth Diffusivity (alpha)   =  1.1  sq.ft./day
Cement thermal cond.        =  10.32  BTU/day degrees F/ft

Casing # 3
Casing  length    (feet)    =  3005
Inside  diameter (inches)   =  12.515
Outside diameter (inches)   =  13.375
Hole     radius   (inches)  =  8.75
Earth Thermal Conductivity  =  7  TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
Cement thermal cond.        =  10.32  BTU/day degrees F/ft

Casing # 4
Casing  length    (feet)    =  2107
Inside  diameter (inches)   =  0
Outside diameter (inches)   =  0
Hole     radius   (inches)  =  6.125
Earth Thermal Conductivity  =  7  TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
```

**** p-24st-1 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1215.0916 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	132.98080	1216.58999	390.11797
2	142.17330	1223.28934	404.59914
3	172.75843	1242.32499	446.29790
4	193.86118	1247.68044	460.72239

Well Name prati-25

Z	=	200.	F(t) =	0.65	U =	71.83	Q =	2.23	Ts =	409.00	Te =	60.00
	=	81.	F(t) =	0.65	U =	71.83	Q =	0.89	Ts =	413.30	Te =	73.22
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.79	Ts =	415.02	Te =	78.55
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.74	Ts =	418.54	Te =	91.75
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.68	Ts =	421.97	Te =	104.95
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.63	Ts =	425.31	Te =	118.15
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.57	Ts =	428.56	Te =	131.35
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.52	Ts =	431.71	Te =	144.55
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.47	Ts =	434.76	Te =	157.75
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.41	Ts =	437.72	Te =	170.95
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.35	Ts =	440.57	Te =	184.15
Z	=	67.	F(t) =	0.83	U =	62.46	Q =	0.44	Ts =	443.32	Te =	197.35
Z	=	200.	F(t) =	0.83	U =	62.46	Q =	1.04	Ts =	444.22	Te =	201.77
Z	=	32.	F(t) =	0.83	U =	62.46	Q =	0.16	Ts =	447.79	Te =	214.97
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.72	Ts =	448.34	Te =	217.08
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.68	Ts =	451.21	Te =	230.28
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.65	Ts =	453.94	Te =	243.48
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.62	Ts =	456.54	Te =	256.68
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.58	Ts =	459.02	Te =	269.88
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.55	Ts =	461.37	Te =	283.08
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.51	Ts =	463.62	Te =	296.28
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.48	Ts =	465.75	Te =	309.48
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.44	Ts =	467.78	Te =	322.68
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.41	Ts =	469.71	Te =	335.88
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.37	Ts =	471.54	Te =	349.08
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.33	Ts =	473.27	Te =	362.28
	=	200.	F(t) =	1.03	U =	42.47	Q =	0.30	Ts =	474.90	Te =	375.48
	=	200.	F(t) =	1.03	U =	42.47	Q =	0.26	Ts =	476.45	Te =	388.68
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.22	Ts =	477.90	Te =	401.88
Z	=	200.	F(t) =	1.03	U =	42.47	Q =	0.18	Ts =	479.27	Te =	415.08
Z	=	170.	F(t) =	1.03	U =	42.47	Q =	0.13	Ts =	480.55	Te =	428.28
Z	=	200.	F(t) =	1.39	U =	0.00	Q =	0.26	Ts =	481.56	Te =	439.50
Z	=	200.	F(t) =	1.39	U =	0.00	Q =	0.18	Ts =	484.59	Te =	452.70
Z	=	200.	F(t) =	1.39	U =	0.00	Q =	0.11	Ts =	487.36	Te =	465.90
Z	=	102.	F(t) =	1.39	U =	0.00	Q =	0.03	Ts =	489.86	Te =	479.10

prati-25 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.066 degrees F/ft
Time From Start of Flow = 8 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 409 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 147.4 psia
Steam Delivery = 211100 lbs/hr

Depth of First Steam Entry = 6452 feet

Casing # 1
Casing length (feet) = 281
Inside diameter (inches) = 15.124
Outside diameter (inches) = 22
Hole radius (inches) = 13
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 1867

```
Inside   diameter (inches)   =  15.124
Outside diameter (inches)   =  16
Hole     radius   (inches)   =  10.25
Earth Thermal Conductivity =  7   TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
Cement thermal cond.        =  10.32  BTU/day degrees F/ft

Casing # 3
Casing  length   (feet)     =  232
Inside  diameter (inches)   =  10.772
Outside diameter (inches)   =  16
Hole     radius   (inches)   =  10.25
Earth Thermal Conductivity =  7   TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
Cement thermal cond.        =  10.32  BTU/day degrees F/ft

Casing # 4
Casing  length   (feet)     =  3370
Inside  diameter (inches)   =  10.772
Outside diameter (inches)   =  11.75
Hole     radius   (inches)   =  7.375
Earth Thermal Conductivity =  7   TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
Cement thermal cond.        =  4.728  BTU/day degrees F/ft

Casing # 5
Casing  length   (feet)     =  702
Inside  diameter (inches)   =  0
Outside diameter (inches)   =  0
Hole     radius   (inches)   =  4.375
Earth Thermal Conductivity =  7   TCU
Earth Diffusivity (alpha)   =  1.2  sq.ft./day
```

**** prati-25 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1224.9430 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	149.31147	1228.06319	415.01506
2	161.72137	1242.66311	444.21919
3	169.80484	1243.87117	448.33915
4	260.77717	1251.28059	481.56312
5	302.10243	1251.85481	491.04367

Well Name prati-27

Z =	220.	F(t) =	0.63	U =	[illegible]	Q =	[illegible]	Ts =	377.00	Te =	[illegible]
Z =	80.	F(t) =	0.63	U =	71.92	Q =	0.78	Ts =	380.50	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.60	Ts =	381.89	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.53	Ts =	384.93	Te =	[illegible]
Z =	120.	F(t) =	0.83	U =	62.46	Q =	1.58	Ts =	387.90	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.53	Ts =	390.76	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.47	Ts =	393.59	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.42	Ts =	396.32	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.37	Ts =	398.96	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.31	Ts =	401.52	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.26	Ts =	403.99	Te =	[illegible]
Z =	200.	F(t) =	0.83	U =	62.46	Q =	1.20	Ts =	406.38	Te =	[illegible]
Z =	96.	F(t) =	0.83	U =	62.46	Q =	0.57	Ts =	408.67	Te =	[illegible]
Z =	200.	F(t) =	0.84	U =	62.46	Q =	0.92	Ts =	409.76	Te =	205.06
Z =	41.	F(t) =	0.84	U =	62.46	Q =	0.18	Ts =	412.95	Te =	217.26
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.55	Ts =	413.58	Te =	219.75
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.52	Ts =	416.07	Te =	231.96
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.49	Ts =	418.44	Te =	244.16
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.46	Ts =	420.71	Te =	256.36
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.44	Ts =	422.87	Te =	268.56
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.41	Ts =	424.94	Te =	280.76
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.38	Ts =	426.91	Te =	292.96
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.35	Ts =	428.79	Te =	305.16
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.31	Ts =	430.58	Te =	317.36
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.28	Ts =	432.28	Te =	329.56
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.25	Ts =	433.91	Te =	341.76
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.22	Ts =	435.45	Te =	353.96
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.19	Ts =	436.91	Te =	366.16
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.16	Ts =	438.29	Te =	378.36
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.12	Ts =	439.60	Te =	390.56
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.09	Ts =	440.84	Te =	402.76
Z =	200.	F(t) =	1.03	U =	35.11	Q =	0.06	Ts =	442.00	Te =	414.96
Z =	10.	F(t) =	1.03	U =	35.11	Q =	0.00	Ts =	443.09	Te =	427.16
Z =	200.	F(t) =	1.27	U =	0.00	Q =	0.08	Ts =	443.14	Te =	427.77
Z =	200.	F(t) =	1.27	U =	0.00	Q =	-0.02	Ts =	444.23	Te =	439.97
Z =	200.	F(t) =	1.27	U =	0.00	Q =	-0.11	Ts =	445.15	Te =	452.17
Z =	200.	F(t) =	1.27	U =	0.00	Q =	-0.21	Ts =	445.92	Te =	464.37
Z =	14.	F(t) =	1.27	U =	0.00	Q =	-0.02	Ts =	446.52	Te =	476.57

prati-27 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.061 degrees F/ft
Time From Start of Flow = 6.5 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 377 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 163.1 psia
Steam Delivery = 199000 lbs/hr

Depth of First Steam Entry = 6843 feet

Casing # 1
Casing Length (feet) = 280
Inside diameter (inches) = 15.124
Outside diameter (inches) = 22
Hole radius (inches) = 13
Earth Thermal Conductivity = 3.7 TCU
Earth Diffusivity (alpha) = 1 sq.ft./day
Cement Thermal cond. = 11 BTU/day degrees F/ft

```
Casing # 2
Casing  length    (feet)      =  2088
Inside  diameter (inches)  =  15.124
Outside diameter (inches)  =  16
Hole     radius   (inches)  =  10.25
Earth Thermal Conductivity =  6.68  TCU
Earth Diffusivity (alpha)  =  1.13  sq.ft./day
Cement thermal cond.       =  10.32  BTU/day degrees F/ft

Casing # 3
Casing  length    (feet)      =  241
Inside  diameter (inches)  =  10.616
Outside diameter (inches)  =  16
Hole     radius   (inches)  =  10.25
Earth Thermal Conductivity =  7  TCU
Earth Diffusivity (alpha)  =  1.2  sq.ft./day
Cement thermal cond.       =  10.32  BTU/day degrees F/ft

Casing # 4
Casing  length    (feet)      =  3410
Inside  diameter (inches)  =  10.616
Outside diameter (inches)  =  11.75
Hole     radius   (inches)  =  7.735
Earth Thermal Conductivity =  7  TCU
Earth Diffusivity (alpha)  =  1.2  sq.ft./day
Cement thermal cond.       =  4.728  BTU/day degrees F/ft

Casing # 5
Casing  length    (feet)      =  814
Inside  diameter (inches)  =  0
Outside diameter (inches)  =  0
Hole     radius   (inches)  =  5.313
Earth Thermal Conductivity =  7  TCU
Earth Diffusivity (alpha)  =  1.2  sq.ft./day
```

**** prati-27 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1202.9779 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	164.55876	1205.74398	381.68919
2	175.36312	1220.75223	409.76134
3	182.43011	1221.85595	413.58421
4	263.24559	1227.15214	443.13793
5	279.04365	1226.88048	446.55373

Well Name prati-30

Z	=	200.	F(t) =	0.64	U =	52.31	Q =	2.18	Ts =	367.20	Te =	[illegible]
Z	=	107.	F(t) =	0.64	U =	52.31	Q =	1.11	Ts =	371.22	Te =	[illegible]
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	2.26	Ts =	373.40	Te =	[illegible]
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	2.19	Ts =	377.79	Te =	[illegible]
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	2.12	Ts =	382.08	Te =	107.37
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	2.05	Ts =	386.24	Te =	120.77
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	1.97	Ts =	392.29	Te =	134.17
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	1.90	Ts =	394.21	Te =	147.57
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	1.82	Ts =	398.20	Te =	160.97
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	1.75	Ts =	401.66	Te =	174.37
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	1.67	Ts =	405.19	Te =	187.77
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	1.59	Ts =	408.59	Te =	201.17
Z	=	75.	F(t) =	0.89	U =	68.89	Q =	0.61	Ts =	411.85	Te =	214.57
Z	=	200.	F(t) =	0.89	U =	68.89	Q =	1.36	Ts =	413.11	Te =	219.66
Z	=	9.	F(t) =	0.89	U =	68.89	Q =	0.06	Ts =	416.61	Te =	220.26
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	1.51	Ts =	416.76	Te =	233.67
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	1.43	Ts =	420.45	Te =	247.07
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	1.34	Ts =	423.96	Te =	260.67
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	1.26	Ts =	427.30	Te =	274.07
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	1.17	Ts =	430.46	Te =	287.47
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	1.08	Ts =	433.45	Te =	300.87
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.99	Ts =	436.26	Te =	314.27
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.90	Ts =	438.90	Te =	327.67
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.80	Ts =	441.36	Te =	341.07
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.71	Ts =	443.64	Te =	354.47
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.61	Ts =	445.74	Te =	367.87
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.51	Ts =	447.67	Te =	381.27
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.41	Ts =	449.42	Te =	394.67
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.31	Ts =	450.99	Te =	[illegible]
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.21	Ts =	452.37	Te =	421.47
Z	=	200.	F(t) =	1.11	U =	106.70	Q =	0.10	Ts =	453.58	Te =	434.87
Z	=	156.	F(t) =	1.11	U =	106.70	Q =	-0.00	Ts =	454.61	Te =	448.27
Z	=	200.	F(t) =	1.38	U =	0.00	Q =	-0.17	Ts =	455.45	Te =	461.62
Z	=	55.	F(t) =	1.38	U =	0.00	Q =	-0.14	Ts =	456.06	Te =	[illegible]

prati-30 wellbore heat loss

**** INPUT DATA ****

Geothermal Gradient = 0.067 degrees F/ft
Time From Start of Flow = 7.75 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 367 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 169.5 psia
Steam Delivery = 117000 lbs/hr

Depth of First Steam Entry = 6288 feet

Casing # 1
Casing Length (feet) = 307
Inside diameter (inches) = 12.05
Outside diameter (inches) = 20
Hole radius (inches) = [illegible]
Earth Thermal Conductivity = 7 [illegible]
Earth Diffusivity (alpha) = 1.2 sq. ft./day
Cement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing Length (feet) = 2079
Inside diameter (inches) = 10.05

Outside diameter (inches) = [illegible]
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq. ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 229
Inside diameter (inches) = 8.835
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq. ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 3398
Inside diameter (inches) = 8.835
Outside diameter (inches) = 9.625
Hole radius (inches) = 6.125
Earth Thermal Conductivity = 7.11 TCU
Earth Diffusivity (alpha) = 1.1 sq. ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 295
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 4.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq. ft./day

**** prati-30 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1195.1872 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	173.78830	1198.42107	373.40319
2	201.24135	1218.35679	413.10713
3	206.21182	1219.77865	416.76256
4	276.01505	1233.09844	455.44654
5	281.56063	1232.79195	456.25607

Well Name pst-31

Z	=	200.	F(t) =	0.59	U =	50.31	Q =	2.23	Ts =	413.00	Te =	[illegible]
Z	=	30.	F(t) =	0.59	U =	50.31	Q =	6.31	Ts =	418.55	Te =	[illegible]
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	2.22	Ts =	420.97	Te =	[illegible]
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	2.17	Ts =	426.66	Te =	[illegible]
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	2.13	Ts =	432.16	Te =	102.13
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	2.08	Ts =	437.46	Te =	114.61
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	2.04	Ts =	442.64	Te =	126.45
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	1.99	Ts =	447.63	Te =	138.6[illegible]
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	1.94	Ts =	452.47	Te =	152.89
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	1.89	Ts =	457.15	Te =	161.09
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	1.84	Ts =	461.70	Te =	175.29
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	1.79	Ts =	466.11	Te =	187.49
Z	=	133.	F(t) =	0.82	U =	68.89	Q =	1.17	Ts =	470.37	Te =	199.69
Z	=	200.	F(t) =	0.82	U =	68.89	Q =	1.56	Ts =	473.14	Te =	207.82
Z	=	82.	F(t) =	0.82	U =	68.89	Q =	0.63	Ts =	477.79	Te =	220.00
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.75	Ts =	479.63	Te =	225.21
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.70	Ts =	484.46	Te =	237.21
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.64	Ts =	489.09	Te =	249.41
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.59	Ts =	493.54	Te =	261.61
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.53	Ts =	497.82	Te =	273.81
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.48	Ts =	501.92	Te =	286.01
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.42	Ts =	505.86	Te =	298.21
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.36	Ts =	509.65	Te =	310.41
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.30	Ts =	513.27	Te =	322.61
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.24	Ts =	516.74	Te =	334.81
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.17	Ts =	520.06	Te =	347.01
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.11	Ts =	523.23	Te =	359.21
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	1.05	Ts =	526.25	Te =	371.41
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	0.98	Ts =	529.12	Te =	383.61
Z	=	200.	F(t) =	1.03	U =	106.70	Q =	0.91	Ts =	531.85	Te =	395.81
Z	=	15.	F(t) =	1.03	U =	106.70	Q =	0.07	Ts =	534.43	Te =	408.01
Z	=	200.	F(t) =	1.26	U =	0.00	Q =	1.38	Ts =	534.61	Te =	408.92
Z	=	200.	F(t) =	1.26	U =	0.00	Q =	1.28	Ts =	538.02	Te =	421.12
Z	=	200.	F(t) =	1.26	U =	0.00	Q =	1.17	Ts =	541.21	Te =	433.32
Z	=	200.	F(t) =	1.26	U =	0.00	Q =	1.07	Ts =	544.20	Te =	445.52
Z	=	200.	F(t) =	1.26	U =	0.00	Q =	0.96	Ts =	546.98	Te =	457.71
Z	=	190.	F(t) =	1.26	U =	0.00	Q =	0.81	Ts =	549.55	Te =	469.32

pst-31 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient	=	0.061 degrees F/ft
Time From Start of Flow	=	5.5 hrs
Earth Temp. at Well Head	=	60 degrees F
Steam Temp. at Well Head	=	413 degrees F
Depth change (delta length)	=	200 feet
Well Head Pressure	=	119.6 psia
Steam Delivery	=	146300 lbs/hr

Depth of First Steam Entry = 6910 feet

Casing # 1

Casing Length (feet)	=	290
Inside diameter (inches)	=	10.05
Outside diameter (inches)	=	20
Hole radius (inches)	=	13
Earth Thermal Conductivity	=	7.5 TCU
Earth Diffusivity (alpha)	=	1.1 sq. ft./day
Cement thermal cond.	=	11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = [illegible]
Inside diameter (inches) = 12.05
Outside diameter (inches) = 13.375
Hole radius (inches) = 6.75
Earth Thermal Conductivity = 7.11 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 282
Inside diameter (inches) = 8.835
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 3015
Inside diameter (inches) = 8.835
Outside diameter (inches) = 9.625
Hole radius (inches) = 6.125
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 1190
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 4.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** pst-31 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1231.5216 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	129.03418	1234.45813	420.97380
2	185.30963	1255.71913	473.13949
3	197.25553	1257.90652	479.63204
4	298.16145	1278.19253	534.61313
5	331.79318	1284.86367	551.78791

Well Name prati-32

Z =	200.	F(t) =	1.27	U =	71.53	Q =	1.96	Ts =	472.00	Te =	[illegible]
Z =	122.	F(t) =	1.27	U =	71.53	Q =	1.15	Ts =	476.29	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.62	Ts =	478.87	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.58	Ts =	482.49	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.55	Ts =	486.02	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.51	Ts =	489.48	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.48	Ts =	492.85	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.44	Ts =	496.14	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.40	Ts =	499.33	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.36	Ts =	502.47	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.33	Ts =	505.52	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.29	Ts =	508.48	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.25	Ts =	511.36	Te =	[illegible]
Z =	191.	F(t) =	1.46	U =	62.46	Q =	1.16	Ts =	514.16	Te =	[illegible]
Z =	200.	F(t) =	1.46	U =	62.46	Q =	1.11	Ts =	516.76	Te =	[illegible]
Z =	80.	F(t) =	1.46	U =	62.46	Q =	0.44	Ts =	519.77	Te =	[illegible]
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.79	Ts =	520.95	Te =	242.57
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.77	Ts =	523.33	Te =	254.77
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.74	Ts =	525.63	Te =	266.97
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.71	Ts =	527.85	Te =	279.17
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.68	Ts =	529.98	Te =	291.37
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.65	Ts =	532.04	Te =	303.57
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.62	Ts =	534.01	Te =	315.77
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.59	Ts =	535.91	Te =	327.97
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.56	Ts =	537.74	Te =	340.17
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.53	Ts =	539.49	Te =	352.37
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.50	Ts =	541.16	Te =	364.57
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.47	Ts =	542.77	Te =	376.77
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.44	Ts =	544.30	Te =	388.97
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.40	Ts =	545.76	Te =	401.17
Z =	200.	F(t) =	1.75	U =	42.47	Q =	0.37	Ts =	547.14	Te =	413.37
Z =	180.	F(t) =	1.75	U =	42.47	Q =	0.31	Ts =	548.46	Te =	425.57
Z =	200.	F(t) =	2.38	U =	0.00	Q =	0.52	Ts =	549.22	Te =	[illegible]
Z =	200.	F(t) =	2.38	U =	0.00	Q =	0.48	Ts =	551.91	Te =	[illegible]
Z =	200.	F(t) =	2.38	U =	0.00	Q =	0.43	Ts =	554.45	Te =	[illegible]
Z =	149.	F(t) =	2.38	U =	0.00	Q =	0.29	Ts =	556.82	Te =	[illegible]

prati-32 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient	=	0.061 degrees F/ft
Time From Start of Flow	=	51 hrs
Earth Temp. at Well Head	=	60 degrees F
Steam Temp. at Well Head	=	472 degrees F
Depth change (delta length)	=	200 feet
Well Head Pressure	=	153.6 psia
Steam Delivery	=	187700 lbs/hr

Depth of First Steam Entry = 6862 feet

Casing # 1

Casing length (feet)	=	322
Inside diameter (inches)	=	12.515
Outside diameter (inches)	=	22
Hole radius (inches)	=	13
Earth Thermal Conductivity	=	7.1 ?CU
Earth Diffusivity (alpha)	=	1.2 sq.ft./day
Cement thermal cond.	=	11 BTU/day degrees F/ft

Casing # 2

[illegible]
Inside diameter (inches) = [illegible]
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 5.8 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 280
Inside diameter (inches) = 10.772
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 3120
Inside diameter (inches) = 10.772
Outside diameter (inches) = 11.75
Hole radius (inches) = 7.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 4.728 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 749
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 4.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** prati-32 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1258.8590 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	158.29060	1262.00601	478.87006
2	190.22147	1278.97139	516.75630
3	197.47592	1280.51700	520.95198
4	265.86854	1289.53130	549.21737
5	304.04924	1291.26233	558.48440

well Name prati-37

Z = 200.	F(t) = 0.65	U = 71.83	Q = 2.91	Ts = 440.00	Te = 60.00
= 200.	F(t) = 0.71	U = 62.46	Q = 2.44	Ts = 445.58	Te = 72.00
Z = 200.	F(t) = 0.71	U = 62.46	Q = 2.39	Ts = 450.32	Te = 84.00
Z = 200.	F(t) = 0.71	U = 62.46	Q = 2.34	Ts = 454.98	Te = 96.00
Z = 200.	F(t) = 0.71	U = 62.46	Q = 2.29	Ts = 459.56	Te = 108.00
Z = 200.	F(t) = 0.71	U = 62.46	Q = 2.24	Ts = 464.05	Te = 120.00
Z = 200.	F(t) = 0.71	U = 62.46	Q = 2.19	Ts = 468.45	Te = 132.00
Z = 90.	F(t) = 0.71	U = 62.46	Q = 0.97	Ts = 472.77	Te = 144.00
Z = 200.	F(t) = 0.83	U = 62.46	Q = 1.70	Ts = 474.69	Te = 149.40
Z = 23.	F(t) = 0.83	U = 62.46	Q = 0.19	Ts = 479.00	Te = 161.40
Z = 200.	F(t) = 1.03	U = 42.47	Q = 1.19	Ts = 479.48	Te = 162.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 1.15	Ts = 482.78	Te = 174.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 1.12	Ts = 485.96	Te = 186.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 1.09	Ts = 489.03	Te = 198.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 1.05	Ts = 492.00	Te = 210.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 1.02	Ts = 494.87	Te = 222.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.98	Ts = 497.64	Te = 234.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.95	Ts = 500.31	Te = 246.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.91	Ts = 502.89	Te = 258.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.87	Ts = 505.38	Te = 270.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.84	Ts = 507.77	Te = 282.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.80	Ts = 510.07	Te = 294.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.76	Ts = 512.28	Te = 306.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.72	Ts = 514.40	Te = 318.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.69	Ts = 516.44	Te = 330.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.65	Ts = 518.39	Te = 342.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.61	Ts = 520.24	Te = 354.78
= 200.	F(t) = 1.03	U = 42.47	Q = 0.57	Ts = 522.02	Te = 366.78
Z = 200.	F(t) = 1.03	U = 42.47	Q = 0.53	Ts = 523.71	Te = 378.78
Z = 59.	F(t) = 1.03	U = 42.47	Q = 0.15	Ts = 525.31	Te = 390.78
Z = 200.	F(t) = 1.39	U = 0.00	Q = 1.08	Ts = 525.76	Te = 394.32
Z = 200.	F(t) = 1.39	U = 0.00	Q = 1.01	Ts = 529.55	Te = 406.32
Z = 200.	F(t) = 1.39	U = 0.00	Q = 0.94	Ts = 533.11	Te = 418.32
Z = 200.	F(t) = 1.39	U = 0.00	Q = 0.86	Ts = 536.45	Te = 430.32
Z = 200.	F(t) = 1.39	U = 0.00	Q = 0.79	Ts = 539.57	Te = 442.32
Z = 200.	F(t) = 1.39	U = 0.00	Q = 0.71	Ts = 542.49	Te = 454.32
Z = 200.	F(t) = 1.39	U = 0.00	Q = 0.63	Ts = 545.20	Te = 466.32
Z = 49.	F(t) = 1.39	U = 0.00	Q = 0.14	Ts = 547.72	Te = 478.32

prati-37 wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient	=	0.06 degrees F/ft
Time From Start of Flow	=	8 hrs
Earth Temp. at Well Head	=	60 degrees F
Steam Temp. at Well Head	=	440 degrees F
Depth change (delta length)	=	200 feet
well Head Pressure	=	144.7 psia
Steam Delivery	=	177000 lbs/hr
Depth of First Steam Entry	=	7021 feet

Casing # 1

Casing length (feet)	=	200
Inside diameter (inches)	=	19.124
Outside diameter (inches)	=	22
Hole radius (inches)	=	13
Earth Thermal Conductivity	=	7 TCU
Earth Diffusivity (alpha)	=	1.2 sq.ft./day
Cement thermal cond.	=	11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 1290
Inside diameter (inches) = 15.124
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 6.39 TCU
Earth Diffusivity (alpha) = 1.05 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 223
Inside diameter (inches) = 10.88
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 3859
Inside diameter (inches) = 10.88
Outside diameter (inches) = 11.75
Hole radius (inches) = 7.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 4.728 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 1449
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 4.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** prati-37 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1242.6457 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	145.74681	1245.55102	445.58010
2	152.47279	1260.43294	474.69279
3	158.39552	1262.32281	479.48273
4	239.93404	1278.97339	525.76256
5	307.64192	1285.13768	548.30250

Well Name prati-38

Z = 200.	F(t) = 0.48	U = 71.83	Q = 2.36	Ts = 363.00	Te = 62.20
Z = 86.	F(t) = 0.48	U = 71.83	Q = 0.99	Ts = 367.31	Te = 72.51
= 200.	F(t) = 0.63	U = 172.74	Q = 2.89	Ts = 369.14	Te = 79.45
= 200.	F(t) = 0.63	U = 172.74	Q = 2.81	Ts = 374.38	Te = 93.05
Z = 200.	F(t) = 0.63	U = 172.74	Q = 2.72	Ts = 379.50	Te = 106.65
Z = 200.	F(t) = 0.63	U = 172.74	Q = 2.63	Ts = 384.50	Te = 120.25
Z = 200.	F(t) = 0.63	U = 172.74	Q = 2.54	Ts = 389.38	Te = 133.85
Z = 181.	F(t) = 0.63	U = 172.74	Q = 2.22	Ts = 394.12	Te = 147.45
Z = 200.	F(t) = 0.71	U = -190.30	Q = 10.52	Ts = 398.29	Te = 159.76
Z = 29.	F(t) = 0.71	U = -190.30	Q = 1.61	Ts = 418.46	Te = 173.36
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.93	Ts = 421.84	Te = 175.33
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.89	Ts = 424.78	Te = 188.93
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.85	Ts = 427.86	Te = 202.53
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.81	Ts = 430.80	Te = 216.13
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.77	Ts = 433.59	Te = 229.73
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.72	Ts = 436.26	Te = 243.33
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.68	Ts = 438.79	Te = 256.93
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.64	Ts = 441.20	Te = 270.53
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.59	Ts = 443.48	Te = 284.13
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.55	Ts = 445.65	Te = 297.73
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.50	Ts = 447.70	Te = 311.33
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.46	Ts = 449.65	Te = 324.93
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.41	Ts = 451.48	Te = 338.53
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.37	Ts = 453.20	Te = 352.13
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.32	Ts = 454.82	Te = 365.73
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.27	Ts = 456.33	Te = 379.33
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.23	Ts = 457.74	Te = 392.93
Z = 200.	F(t) = 0.71	U = 42.47	Q = 0.18	Ts = 459.04	Te = 406.53
= 200.	F(t) = 0.71	U = 42.47	Q = 0.13	Ts = 460.25	Te = 420.13
Z = 36.	F(t) = 0.71	U = 42.47	Q = 0.02	Ts = 461.35	Te = 433.73
Z = 200.	F(t) = 0.96	U = 0.00	Q = 0.21	Ts = 461.54	Te = 436.18
Z = 200.	F(t) = 0.96	U = 0.00	Q = 0.07	Ts = 462.87	Te = 449.78
Z = 178.	F(t) = 0.96	U = 0.00	Q = -0.06	Ts = 463.94	Te = 463.38

prati-38 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.068 degrees F/ft
Time From Start of Flow = 3.66 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 363 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 134.7 psia
Steam Delivery = 194000 lbs/hr

Depth of First Steam Entry = 6110 feet

Casing # 1
Casing length (feet) = 286
Inside diameter (inches) = 15.124
Outside diameter (inches) = 22
Hole radius (inches) = 13
Earth Thermal Conductivity = 7 TCU
arth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 1181
Inside diameter (inches) = 15.124
Outside diameter (inches) = 16
Hole radius (inches) = 8.75

Earth Diffusivity (alpha) = 1.08 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 229
Inside diameter (inches) = 10.88
Outside diameter (inches) = 16
Hole radius (inches) = 7.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 3836
Inside diameter (inches) = 10.88
Outside diameter (inches) = 11.75
Hole radius (inches) = 7.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 4.728 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 578
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 5.313
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** prati-38 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1200.2952 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	136.40774	1203.64670	369.13691
2	143.41745	1219.46338	398.28762
3	150.35113	1231.59303	421.53967
4	240.79821	1241.89878	461.53777
5	253.00918	1242.12727	464.67691

well Name prati-39

Z	F(t)	U	Q	Ts	Te
200.	0.31	67.39	3.54	402.00	52.44
71.	0.31	67.39	1.25	408.30	72.6[illegible]
200.	0.47	62.46	2.92	410.53	77.47
200.	0.47	62.46	2.85	415.81	[illegible]
200.	0.47	62.46	2.79	421.01	102.27
200.	0.47	62.46	2.72	426.12	114.87
200.	0.47	62.46	2.65	431.13	127.47
200.	0.47	62.46	2.58	436.04	140.07
200.	0.47	62.46	2.51	440.86	152.67
200.	0.47	62.46	2.44	445.56	165.27
200.	0.47	62.46	2.37	450.16	177.87
116.	0.47	62.46	1.35	454.64	190.47
200.	0.47	62.46	1.77	457.19	197.78
33.	0.47	62.46	0.29	461.36	210.36
200.	0.61	35.11	1.02	462.04	212.46
200.	0.61	35.11	0.98	464.82	225.06
200.	0.61	35.11	0.94	467.49	237.66
200.	0.61	35.11	0.90	470.05	250.26
200.	0.61	35.11	0.85	472.51	262.86
200.	0.61	35.11	0.81	474.87	275.46
200.	0.61	35.11	0.77	477.13	288.06
200.	0.61	35.11	0.72	479.28	300.66
200.	0.61	35.11	0.68	481.34	313.26
200.	0.61	35.11	0.64	483.29	325.86
200.	0.61	35.11	0.59	485.15	338.46
200.	0.61	35.11	0.54	486.90	351.06
200.	0.61	35.11	0.50	488.56	363.66
200.	0.61	35.11	0.45	490.13	376.26
200.	0.61	35.11	0.41	491.59	388.86
200.	0.61	35.11	0.36	492.96	401.46
200.	0.61	35.11	0.31	494.23	414.06
200.	0.61	35.11	0.26	495.40	426.66
200.	0.61	35.11	0.21	496.48	439.26
33.	0.61	35.11	0.03	497.46	451.86
200.	0.81	0.00	0.61	497.61	453.94
200.	0.81	0.00	0.44	499.33	466.54
32.	0.81	0.00	0.05	500.71	479.14

prati-39 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.063 degrees F/ft
Time From Start of Flow = 2 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 402 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 154.4 psia
Steam Delivery = 159000 lbs/hr

Depth of First Steam Entry = 6685 feet

Casing # 1
Casing length (feet) = 271
inside diameter (inches) = 15.124
Outside diameter (inches) = 22
Hole radius (inches) = 13
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 1916
Inside diameter (inches) = 15.124
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
ement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 233
Inside diameter (inches) = 10.772
Outside diameter (inches) = 16
Hole radius (inches) = 10.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 3833
Inside diameter (inches) = 10.772
Outside diameter (inches) = 11.75
Hole radius (inches) = 7.735
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 4.728 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 432
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 5.313
Earth Thermal Conductivity = 7 TCU
arth Diffusivity (alpha) = 1.2 sq.ft./day

**** prati-39 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1219.7317 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	155.43009	1224.51641	410.52916
2	162.80936	1249.69385	457.18919
3	167.67697	1251.74725	462.03792
4	234.65190	1263.72527	497.61469
5	241.54162	1264.82833	500.90767

Well Name prati-50

Z	F(t)	U	Q	Ts	Te
200.	0.59	71.83	3.03	378.00	60.00
81.	0.59	71.83	1.22	383.46	71.00
200.	0.81	503.06	4.67	385.66	75.46
200.	0.81	503.06	4.63	394.06	86.46
200.	0.81	503.06	4.59	402.46	97.46
200.	0.81	503.06	4.55	410.88	108.46
200.	0.81	503.06	4.51	419.30	119.46
200.	0.81	503.06	4.47	427.71	130.46
200.	0.81	503.06	4.43	436.11	141.46
200.	0.81	503.06	4.39	444.49	152.46
200.	0.81	503.06	4.35	452.84	163.46
45.	0.81	503.06	0.98	461.16	174.46
200.	0.81	503.06	4.07	463.05	176.93
25.	0.81	503.06	0.51	471.67	187.93
200.	0.85	42.94	1.35	472.75	189.31
200.	0.85	42.94	1.31	476.20	200.31
200.	0.85	42.94	1.28	479.55	211.31
200.	0.85	42.94	1.24	482.79	222.31
200.	0.85	42.94	1.20	485.92	233.31
200.	0.85	42.94	1.16	488.95	244.31
200.	0.85	42.94	1.12	491.89	255.31
200.	0.85	42.94	1.08	494.72	266.31
200.	0.85	42.94	1.04	497.45	277.31
200.	0.85	42.94	1.00	500.09	288.31
200.	0.85	42.94	0.96	502.63	299.31
200.	0.85	42.94	0.92	505.08	310.31
200.	0.85	42.94	0.88	507.43	321.31
200.	0.85	42.94	0.84	509.68	332.31
200.	0.85	42.94	0.79	511.84	343.31
200.	0.85	42.94	0.75	513.90	354.31
200.	0.85	42.94	0.70	515.87	365.31
49.	0.85	42.94	0.17	517.75	376.31
200.	1.07	0.00	1.80	518.19	379.00
200.	1.07	0.00	1.71	522.11	390.00
200.	1.07	0.00	1.61	525.83	401.00
200.	1.07	0.00	1.51	529.36	412.00
200.	1.07	0.00	1.40	532.69	423.00
200.	1.07	0.00	1.30	535.81	434.00
200.	1.07	0.00	1.19	538.73	445.00
130.	1.07	0.00	0.72	541.44	456.00

prati-50 Wellbore Heat Loss

**** INPUT DATA ****

Geothermal Gradient = 0.055 degrees F/ft
Time From Start of Flow = 2.58 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 378 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 131 psia
Steam Delivery = 147800 lbs/hr

Depth of First Steam Entry = 7330 feet

Casing # 1
Casing length (feet) = 281
Inside diameter (inches) = 15.124
Outside diameter (inches) = 22
Hole radius (inches) = 13
Earth Thermal Conductivity = 7 TCU

Earth Diffusivity (alpha) = 2.2 sq.ft./day
Cement thermal cond. = 11 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 1845
Inside diameter (inches) = 15.124
Outside diameter (inches) = 16
ole radius (inches) = 8.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 2.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 225
Inside diameter (inches) = 10.772
Outside diameter (inches) = 16
Hole radius (inches) = 8.25
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 2.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 3449
Inside diameter (inches) = 10.772
Outside diameter (inches) = 11.75
Hole radius (inches) = 7.375
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 2.2 sq.ft./day
Cement thermal cond. = 4.78 BTU/day degrees F/ft

Casing # 5
Casing length (feet) = 1530
Inside diameter (inches) = 0
Outside diameter (inches) = 0
Hole radius (inches) = 5.313
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 2.2 sq.ft./day

**** prati-50 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1209.9519 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	132.07158	1214.19485	385.66392
2	139.29676	1255.76497	463.04869
3	144.17139	1260.35372	472.75199
4	206.29562	1278.15449	518.19370
5	230.60917	1289.38021	543.08968

Well Name pst-54

Z =	137.	F(t) =	0.49	U =	45.28	Q =	2.44	Ts =	368.00	Te =	60.00
=	200.	F(t) =	0.62	U =	47.20	Q =	3.30	Ts =	372.33	Te =	71.65
Z =	200.	F(t) =	0.62	U =	47.20	Q =	3.18	Ts =	378.27	Te =	88.65
Z =	200.	F(t) =	0.62	U =	47.20	Q =	3.05	Ts =	384.03	Te =	105.65
Z =	200.	F(t) =	0.62	U =	47.20	Q =	2.92	Ts =	389.61	Te =	122.65
Z =	200.	F(t) =	0.62	U =	47.20	Q =	2.79	Ts =	394.99	Te =	139.65
Z =	163.	F(t) =	0.62	U =	47.20	Q =	2.18	Ts =	400.17	Te =	156.65
Z =	200.	F(t) =	0.83	U =	68.89	Q =	2.86	Ts =	404.24	Te =	170.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	2.72	Ts =	409.60	Te =	187.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	2.56	Ts =	414.71	Te =	204.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	2.41	Ts =	419.56	Te =	221.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	2.25	Ts =	424.15	Te =	238.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	2.09	Ts =	428.47	Te =	255.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	1.93	Ts =	432.50	Te =	272.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	1.76	Ts =	436.23	Te =	289.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	1.58	Ts =	439.66	Te =	306.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	1.41	Ts =	442.77	Te =	323.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	1.23	Ts =	445.56	Te =	340.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	1.04	Ts =	448.01	Te =	357.50
Z =	200.	F(t) =	0.83	U =	68.89	Q =	0.85	Ts =	450.13	Te =	374.50
Z =	111.	F(t) =	0.83	U =	68.89	Q =	0.39	Ts =	451.89	Te =	391.50
Z =	200.	F(t) =	1.14	U =	0.00	Q =	0.94	Ts =	452.71	Te =	400.94
Z =	184.	F(t) =	1.14	U =	0.00	Q =	0.58	Ts =	454.85	Te =	417.94

pst-54 Wellbore Heat Loss

**** INPUT DATA ****

eothermal Gradient = 0.085 degrees F/ft
Time From Start of Flow = 6 hrs
Earth Temp. at Well Head = 60 degrees F
Steam Temp. at Well Head = 368 degrees F
Depth change (delta length) = 200 feet
Well Head Pressure = 125.7 psia
Steam Delivery = 85200 lbs/hr

Depth of First Steam Entry = 4395 feet

Casing # 1
Casing length (feet) = 137
Inside diameter (inches) = 12.515
Outside diameter (inches) = 30
Hole radius (inches) = 18
Earth Thermal Conductivity = 8.5 TCU
Earth Diffusivity (alpha) = 1.5 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 2
Casing length (feet) = 1163
Inside diameter (inches) = 12.515
Outside diameter (inches) = 20
Hole radius (inches) = 13
Earth Thermal Conductivity = 7.8 TCU
arth Diffusivity (alpha) = 1.3 sq.ft./day
ement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 3
Casing length (feet) = 2711
Inside diameter (inches) = 12.515
Outside diameter (inches) = 13.375
Hole radius (inches) = 8.75

Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day
Cement thermal cond. = 10.32 BTU/day degrees F/ft

Casing # 4
Casing length (feet) = 384
Inside diameter (inches) = 0
utside diameter (inches) = 0
Hole radius (inches) = 5.313
Earth Thermal Conductivity = 7 TCU
Earth Diffusivity (alpha) = 1.2 sq.ft./day

**** pst-54 RESULTS ****

NOTE: First Steam Entry is Bottom of Last Casing

Enthalpy at Wellhead 1205.1441 BTU/lbm

Casing #	Pressure (psia)	Enthalpy (BTU/lbm)	Temperature (deg. F)
1	126.19693	1207.57962	372.32701
2	130.45172	1225.00451	404.24321
3	140.43917	1250.09466	452.71182
4	143.57649	1251.62267	456.28527