ThermaSource INC.
GEOTHERMAL CONSULTING SERVICES

WELL TEST REPORT
PUEBLO VALLEY 66-22A
NOVEMBER 2, 1993

Copy 2

FOR

ANADARKO PETROLEUM COMPANY
835 Piner Road
Santa Rosa, CA 95401

January 5, 1994

725 Farmers Lane • P.O. Box 1236 • Santa Rosa, California 95402 • (707) 523-2960 • FAX (707) 523-1029

WELL TEST REPORT
PUEBLO VALLEY 66-22A

SUMMARY

On November 2, 1993, a flow test was conducted on Pueblo Valley 66-22A located near Fields, Oregon. This well is a stepout to Anadarko's discovery Well 25-22A. Pueblo Valley 66-22A was drilled with a core rig to a total depth of 2376'. The well was completed with 4-1/2" casing set to 1007'. The open hole interval from 1007' to 2376' was drilled with an HQ(3.8") diamond core bit. During the four hour flow period through a 4" flow-line, the combined flow rate of steam and hot water stabilized at 292 GPM (12% flash). At the end of the test, wellhead temperature was 296 degrees F and flowing wellhead pressure was 62 psig.

Maximum downhole temperature was 325 degrees F at 2076', corresponding to the presence of a lost circulation zone during drilling. This zone was most likely the major source of production during the flow test. Observation of the recovered core samples suggest that other production zones are present below 2076', however, the logging instruments encountered an obstruction at 2200' and thus data below this point were not obtained. During the flow period, maximum drawdown was 8.8 psi, from an initial pressure of 932.2 psia, indicating that the well is capable of much higher producing rates with more drawdown. Figure 1 shows the surface and downhole data as they were collected in 15 minute intervals during the flow test.

During the last 45 minutes of flow, the flowing downhole pressure stabilized and then increased. This is similar to the behavior experienced on Well 25-22A. However, this time clay swelling in the uncased portion of the wellbore may be the cause rather than scaling. Confirmation of this was received after the flow period when the downhole instruments would not go past a claystone and siltstone interval at 1218'. Another possible explanation might be that a productive interval started to flow from below, causing the pressure at 2100' to increase and the temperature to decrease.

The well was shut-in at 2:15 pm, and the pressure at 2100' was measured. Pressure recovered only 2 psi in almost one hour which is very uncharacteristic of fractured systems. Because the spinner instrument was not operating, there was no way to determine if fluid movement was occurring following the usual after-flow period. Thus estimates of transmissivity (KH) for the producing interval could not be reliably estimated. By utilizing various methods on the available data, KH was found to range from 28,000 md-ft to 580,000 md-ft. Based on the fact that less than 1% drawdown was observed, it is my opinion

that 28,000 md-ft is too low and 580,000 md-ft is too high for true formation transmissivity. This is corroborated somewhat in that high skin factors accompany the high KH values while minus skin factors accompany the low KH values.

TEST RESULTS

Prior to flowing the well, a Tasco Logging Service pressure-temperature-spinner (PTS) tool with Gamma Ray (GR) was inserted into the well to measure static downhole conditions. Due to operational problems with the spinner, the tool was run without the spinner during the test. Further, an obstruction to the tools was encountered at 2200', so no information below that depth was obtained. Figures 3 & 4 are the temperature and pressure profiles respectively of the well prior to discharge. Static temperature reached a maximum of 325 degrees F at 2076' and then reversed and decreased to 280 degrees F at 2197'. The logging tools were then placed at 2100' to monitor pressure during the flow period.

Discharge of the well was started at 10:15 am on November 2, 1993, and continued for four hours. Figure 2 is a Schematic Flow Diagram of the Test. Effluent from the well was piped to a separator and discharged into a Baker tank. Water flow was gauged through a weir box and also through sight gauges installed on the tanks. Figure 5 is a plot of the data measured at the surface. Water production averaged 257 GPM for the last half of the test. This is a total withdrawal of 292 GPM with a flash fraction of 12%. The wellhead pressure and temperature gauge readings were fluctuating, but within a narrow range normally expected, and so are considered to be stable. Figure 6 is a plot of the downhole pressure during the flow period. Although flow rate stabilized after 1.75 hours, downhole pressure continued to drawdown until 3.25 hours into the test. At that point, pressure started to stabilize and then increase very slightly. It is not apparent from the data whether the well was stabilizing on its own and then some external source caused the pressure to increase or if the external source caused the pressure to both stabilize and increase. Given the fact that the logging tools would not go past 1218' after the flow period, clay swelling would seem to be a reasonable explanation except for the fact that a restriction between the surface and the producing interval should have caused wellhead pressure to decrease and production to decrease. Neither occurred. It is also true that the pressure changes were small and that supporting evidence may not have been detected because of the fluctuating gauge readings. Another explanation might be that some productive interval below 2076' started to flow and supported the downhole pressure. This is consistent with the slight increase in wellhead pressure and slight decrease in downhole temperature.

After four hours of flow the well was shut-in at 2:15 pm. The subsequent pressure buildup was extremely slow and uncharacteristic of a high permeability fractured system. After 51 minutes the downhole pressure had only recovered 2 psi. The pressure instrument was pulled out of the hole in order to pick up the spinner and go back to bottom to check for cross flow. As mentioned, the instrument would not go past 1218'. This is an area of claystones and siltstones and could have swelled when contacted by formation water. No further data were collected on this well.

The slowness of the pressure buildup suggests that more than one zone was flowing just before shut-in, and this created some crossflow just after shut-in. Analysis of the pressure buildup shown in Figure 7 clearly shows two data sets with the pressures building at a very slow pace. What was expected in terms of pressure buildup was observed during the well cleanout discharge the prior night. Although the discharge was brief, the pressure recovery was 20 psi in the space of about 12 minutes.

Further evidence to suggest crossflow may be found in the fact that the wellhead pressure recovered faster than the pressure at 2100'. It is likely the obstruction at 2200' allowed only a fraction of the total flow to move downward. As the pressure in the lower zones equalized with the upper zone, the pressure at 2100' started to build. Unfortunately the spinner instrument was not in operation during the pressure buildup to observe what happened.

Because the pressure buildup never did get out of the transient flow region, a semi-log plot could not be used to determine KH. Even type-curve solutions are not reliable because the pressure data never deviates from the constant slope region. Thus transient pressure analysis of the drawdown and buildup data provide very different and probably unreliable estimates of reservoir properties. Various methodologies were applied to the available pressure data, but each analysis method yielded a different answer. Listed below are the range of results strictly for information purposes.

	KH (md- ft)	Skin
Drawdown Analysis during flow.		
Type-Curve Analysis:	130,000	-1.2
Semi-log analysis:	28,000	-2.1
Buildup Analysis.		
Type-Curve Analysis:	580,000	27.1
Semi-log analysis:	-	-

Pre-Discharge Buildup Analysis.

Semi-log analysis: 28,000 -

Among all of these estimates my opinion is that something in the 100,000 to 200,000 md-ft range would be reasonable for this well. This is based on the fact that less than 1% drawdown was necessary to achieve the observed flow rates, and the rates were not decreasing as fast as the pressure. It should be noted that a fracture with a .001 inch opening has a native permeability of 54,000 md.

The wellhead pressure at Well 25-22A was being measured before, during, and after the flow test. No indication of pressure response was observed. The high permeability around 25-22A coupled with the relatively small amount of reservoir withdrawal and distance would make a response highly unlikely.

COMPARISONS TO 25-22A

The following comparisons may be made with Pueblo Valley 25-22A.

	66-22A	25-22A
Temperature(deg F)	325	310
Depth to production(ft)	2076	1100
Total flow rate(GPM)	292	400
Productivity Index(PI)	29	100
KH(md-ft)	?	>1,000,000
Skin Factor	?	-.12

CONCLUSIONS

1. Pueblo Valley 66-22A produced 325 F hot water at a rate of 292 GPM from a zone at 2076'.

2. Reliable estimates of transmissivity are not available due to cross flow and other possible wellbore effects. The best estimate at this time is a value between 100,000 and 200,000 md-ft.

3. There is a probability that other fractured zones below 2200' are also productive.

4. The well has artesian pressure of 64 psig at static conditions.

5. The well produced at a total withdrawal rate of 292 GPM with a drawdown of 8.8 psi. Assuming a linear productivity index (PI), the well would be capable of 2000 GPM

with a drawdown of 60.3 psi.

6. There are multiple obstructions in the well that preclude any further logging. The well will need to be cleaned out if further evaluation is desired.