Analysis About Low Performance in Some Zones of Los Humeros, México, Geothermal Field

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ABSTRACT

The Los Humeros Mexican geothermal field is a high enthalpy production field. However it has undergone a drastic change in productive characteristics between the north and central zone with respect to the southern producing zone also known as Collapse Central. It seems that the geologic structures and the unfavorable balance between the production and the recharge mass play a main role. Temperature profiles in wells drilled in this area were analyzed and reviewed and were obtained measurements close to 300 °C. However it was found that lost circulation profiles show different behaviors, between the well H1 and the other wells located to east of “Mastaloya” fault. From a view point of reservoir engineering it seems that this area is bounded by the three main geological structures, is of high temperature (about 300 °C), but without permeability characteristics. As a practical application of this study appears interesting the proposal for application of secondary recovery techniques or Enhanced Geothermal System (EGS), including the idea for starting with the methodologies for extracting the heat to the surface for its use in energy generation.

Introduction

In the reservoir engineering, the knowledge of the rock formation properties and the physicochemical parameters are the base for its characterization. Reservoir characterization models are used to simulate the behavior of the fluids within the reservoir under different sets of circumstances and to find the optimal production techniques that will maximize the production. Besides, reservoir characterization is being used as a useful technical tool for reserves determination, knowledge of its initial conditions, design of its exploitation, determination of useful life, among others. A reliable characterization of the reservoir at its initial conditions can be done through the knowledge of parameters such as temperature, pressure, formation mineralogy, porosity and permeability, among others. Angerer et al., (2002) studied the influence of the main structures of the reservoir on the pressure behavior. An ordinary geothermal system is composed by rock formation with enough porosity and permeability characteristics, associated with geological structures forming a seal and a basement, containing fluid at high pressure, temperature and enthalpy. However sometimes not all these factors are found gathered in the system (DOE, 2007). So, it can be found reservoirs with high permeability but low temperature, or with high temperature but scarce permeability. The studied zone in this work is at the southern side of Los Humeros, México geothermal field. The analysis developed was focused to search for explanations about the scarce productive behavior of this area.

The Los Humeros geothermal field is located in the borders between the states of Puebla and Veracruz at central-eastern México (Figure 1) at about 220 km to east of México City. The field is inside the Los
Humeros volcanic caldera, which lies at the eastern end of the Mexican Volcanic Belt near the limit of this province with the Sierra Madre Occidental province (Ferriz and Mahood, 1984; Viggiano 1988; Gutiérrez-Negrín, et al. 2010; Izquierdo et al., 2011).

Los Humeros is one of the four geothermal fields currently operating in México. It has an installed capacity of 40 MWe with eight back-pressure units of 5 MWe each, which are fed by an average of 20 production wells that produce around 500 tons of steam per hour. There are also three injection wells in operation (Flores-Armenta et al., 2010). The geothermal field is administered by the Comisión Federal de Electricidad (CFE) of México. The study area is located at south zone of the field, having as domain structures “Los potreros” Collapse, “Mastaloya” fault and “Las víboras” fault.

**Studied Area**

Into the study area are located the wells H1, H23, H25, H26 and H27 (Cedillo, 2000), whose parameters used in this work were obtained during drilling and completion stage. In general terms this field is characterized by low permeability, which is evident in well production, tests showing low water/steam ratio. Los Humeros wells produce mainly high steam enthalpy (more than 2000 kJ/kg) except well H1 that produces mainly water with enthalpy of 1100 – 1300 kJ/kg this is the only one well showing high water/steam ratio (Bernard-Romero and Taran, 2010). Another striking feature is related with the clearly defined unproductive zone bounded by the three faults mentioned above.

The well H1 is located at the west of “Mastaloya” fault into passage formed by the faults “Mastaloya” and “Antigua”. In this same passage are located wells H6, H12, H13, H18 and H39, all with productive characteristics. However the wells located at east zone of “Mastaloya” fault and bounded at north by the “Las víboras” fault and to east by “Los Potreros” Collapse (H23, H25, H26 and H27) exhibit high temperature but not, productive characteristics.

The control variables present in producing wells are, high temperature, permeability thickness in production zone, association with circulation losses during drilling of about 50 m$^3$/h and the geothermal mass flow. However in unproductive wells, only high temperature was evident without geothermal mass flow and without permeability at the deeper portions of the well. Lost circulation in unproductive wells, only was found at shallow depths and were of limited thickness.

**Wells With Only High Temperature**

The wells located at south zone of exploitation area of Los Humeros geothermal field and to eastern side of “Mastaloya” fault, ordinarily show high temperatures at depths greater than those wells located at western side of this same fault.

In order to demonstrate the behavior of the analyzed parameters in the studied area were used profiles of temperature, and circulation losses during drilling. So, Figure 2 shows the profiles of the well H1 as representative of productive characteristics area. While Figures 3, 4 and 5 show analysis profiles of wells H23, H25 and H26, corresponding to unproductive area.

As mentioned before representative circulation losses (more or less 50 m$^3$/h) were found near surface in all wells located at unproductive zone as can be seen in Figures 3 to 5. Last thing, allows the assumption that geologic structures located in this area play a definitive role for permeability presence and the water entrance into the reservoir by upwelling.
Due to above conditions, it can be assumed that there is a lack of water entrance, therefore there is not recharge to reservoir and there are not appropriate conditions for presence of production characteristics. Viggiano and Robles (1988) carried out analysis of this area in order to correlate high temperature with rock minerals. A comparative correlation between wells of the analyzed area and the well H1 is shown in Figure 6 through a cross section E-W in this zone. So, as can be seen the involved wells are from east to west; H25, H23, H26 and H1.

It can be seen that all wells included in this analyzed section, show increase of temperature with depth. There is a marked difference in the increase of temperature in the well H1, with respect to wells located at eastern side of “Mastaloya” fault. Besides the temperature increase in well H1 occurs at shallower depths than in the other analyzed wells. In relation with lost circulation all these wells show low values of lost circulation at depth, with exception of H1. The drilling fluid circulation losses in wells located to east “Mastaloya” fault were found at depths near surface. It can be seen in the map of Figure 1, that the well H1 can be considered apart from the other wells of this section. “Mastaloya” fault in this case acts as fault block separator in the reservoir structure.

Discussion

The lack of permeability conditions in the reservoir influences in two manners; a) Null or poor entrance of recharge fluid to the geothermal reservoir and, b) Low characteristics of production parameters. By this reason, even prevailing temperatures about 300 °C or greater, there are not productive conditions. Therefore the stored heat underground can be used by secondary recovery technologies (Sanyal and Butler, 2005), such as reservoir stimulation, formation fracturing and other nonconventional methods for extracting only the heat in order to use it at surface. Another idea taking into account the stored heat in the reservoir is focused to appropriate application of technique Enhanced Geothermal System (EGS). For it is necessary when starting a formal project for evaluating the reserves that economic balance is considered in the overall project feasibility.
To date the EGS are conceptualized by using wells for recovering the thermal resource, a small subset of the factors that may influence in its construction are:

- Resource depth
- Influence of lithological variation on drilling
- Influence of lithological variation on well completion
- Influence of lithological variation on stimulation
- In-situ stress state influence on stimulation
- Presence of natural fracture features
- Stimulation methodology used to create reservoir volume and surface area
- Production strategy
- Intervention strategy

Different studies (Pritchett, 1998) show that pressure recovery occurred much faster than temperature re-establishment. Under this concept it is appropriate to select the best methodology for the enhanced recovery of geothermal resource. And not only results enough select the appropriate method for geothermal resource recovery (O’Sullivan and Mannington, 2005), during the practical application in the field, such that each portion of the reservoirs particular characteristics are taken into account and its behavior must be monitored.

Conclusions

According with the analyses done through the development of this work, we submit the following conclusions:

The study shows that geological structures play a major role in the productivity of this geothermal field.

The studied zone, of Los Humeros geothermal field, bounded by “Mastaloya” fault at west, “Las Víboras” fault at north, and “Los Poteros” Collapse at the south shows bottom temperatures, greater than 300 °C, but minimal loss of circulation during drilling.

Systematically, losses circulation greater than 50 m³/h, were found in wells of studied area at depths near of surface. But by lack of fluid losses circulation at depth of production zone, the permeability is poor and therefore there are not fluid entries and recharge to reservoir is null, these conditions are not appropriate conditions for conventional high enthalpy geothermal production.

Using information of the analyzed cross section E-W in the south zone of the Los Humeros field, it seems that the production thickness is located at about 1500 masl. However the analyzed wells did not show productive characteristics at these intervals.

It is appropriate to emphasize in a review of the main structures in the zone that influence in the wells productivity performance, because the knowledge of geological structural array and associated permeability characteristic are necessary to locate new wells with higher probability for successful results.

An idea for application in reservoir formations with poor permeability could be proposed the use of secondary recovery techniques or start with the introduction of methodologies for heat extracting and its conduction to the surface for use in energy generation. According with high temperature and low permeability found, an integral analyzed project of enhanced geothermal system would be appropriate for applying in this geothermal field.

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