



# PHYSICAL-CHEMICAL MODEL OF THE LOS HUMEROS GEOTHERMAL RESERVOIR, MÉXICO

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## ABSTRACT

The Los Humeros geothermal field is located on the eastern side of central Mexico approximately 25 km NW of Perote city in the State of Puebla, inside the volcanic complex of caldera type in the oriental part of the Mexican volcanic belt of the Plio-quaternary one. In the present work departing from updated information of the download fluids of a wells section (H-012, H-015, H-016, H-017, H-019, H-039) of the Los Humeros geothermal reservoir, Puebla, México, provided by the C.F.E. (2007), we identified that the Los Humeros geothermal reservoir is of vapor dominated thermodynamic state. This thermodynamic condition is compatible with the temperature profile of the reservoir, as observed in the average homogenization temperatures determined from the fluid inclusions study (in the deepest zone  $T_h = 337^\circ\text{C}$ ) and in the stabilized temperatures from wells (in the deepest zone  $T_s = 300^\circ\text{C}$ ).

In a similar way departing of updated information of chemical composition of the unload fluids of the same wells section of the Los Humeros geothermal field, equally provided by the C.F.E. (2007), we elaborated the anions, cations and gases graphics proposed by Giggenbach (1988) like that like Giggenbach and Goguel, (1989), identifying that in the reservoir exist two types of fluids (or two reservoirs) meteoric and of magmatic origin, which have not reached the geochemical equilibrium with the minerals of the reservoir, but they are in process of reaching it, situation that corresponds to a geothermal reservoir of recent origin.

## INTRODUCTION

The Los Humeros geothermal deposit is located in the eastern part of central Mexico approximately 25 km northwest of Perote city of in the State of Puebla (Figure 1), inside the Plioquaternary volcanic caldera complex with less than 500 000 years of age ). This complex is located in the eastern part of the Mexican Volcanic belt.

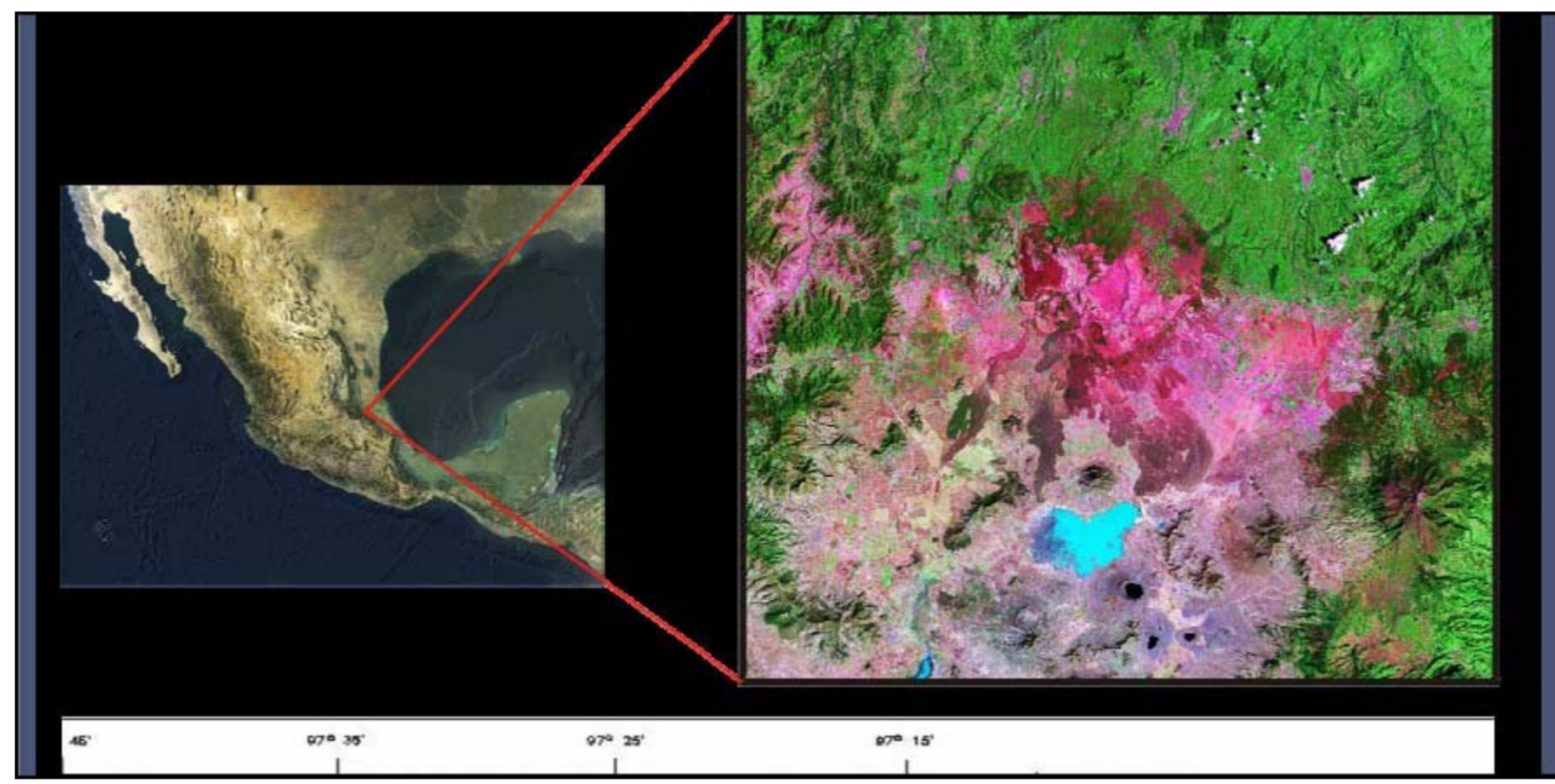


Figure 1: Location of the geothermal area of Los Humeros, Mexico

## THERMODYNAMIC STATE FROM THE GEOTHERMAL FIELD

Based on updated data of enthalpy of the download fluids of a wells section (H-012, H-015, H-016, H-017, H-019, H-039) from the Los Humeros geothermal deposit, Puebla, Mexico, provided by the CFE (2007), in the figures 2 and 3 can be seen that reservoir fluids presented enthalpy values greater than 2400 J/g, which correspond to a thermodynamic state steam, indicating it that the Los Humeros geothermal reservoir has a dominant steam thermodynamic condition (Gonzalez Partida et al, 2001; Tello, 2005).

Significantly, this phenomenon steam in a geothermal reservoir can be accentuated by overexploitation (extraction of brine without sufficient recharge) of the reservoir (Gonzalez Partida et al., 2001; Tello, 2005).

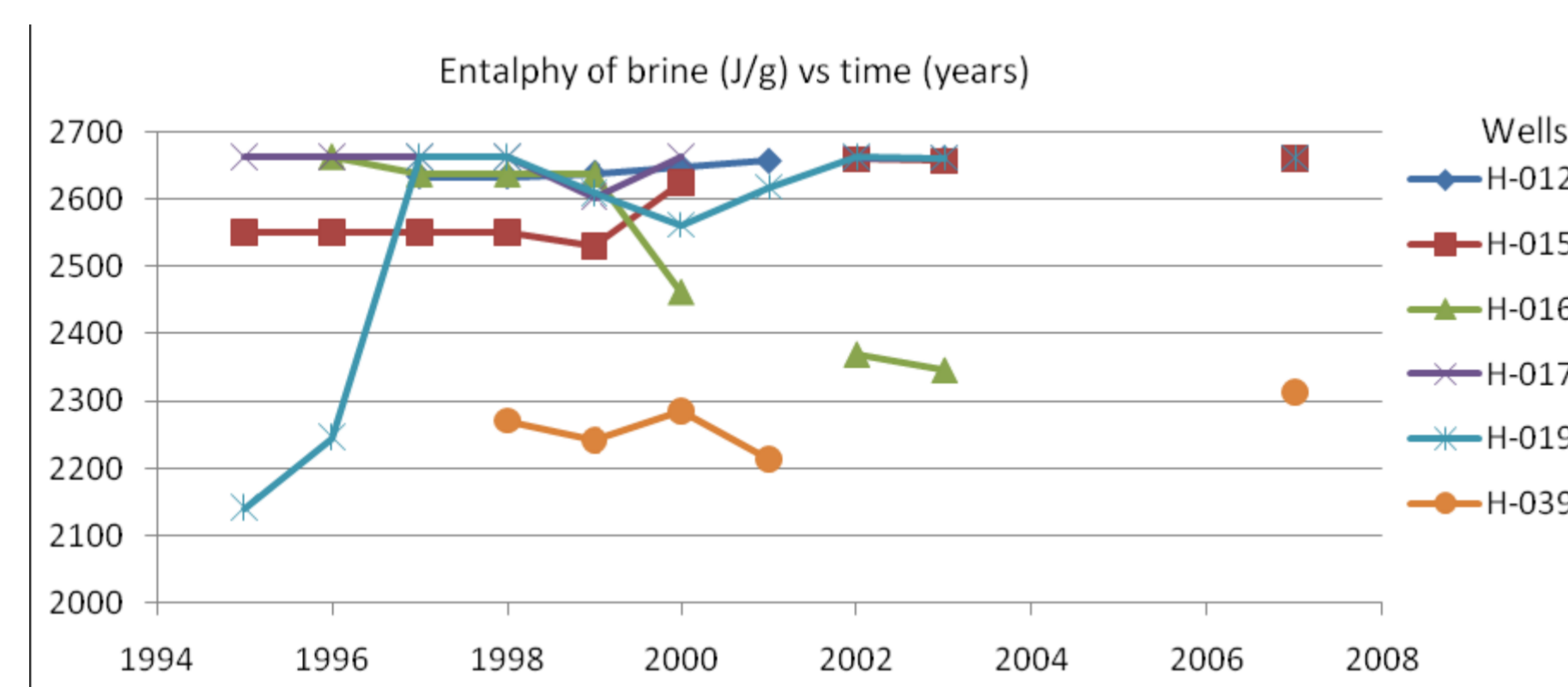


Figure 2: shows updated enthalpy values of brine reservoir against time

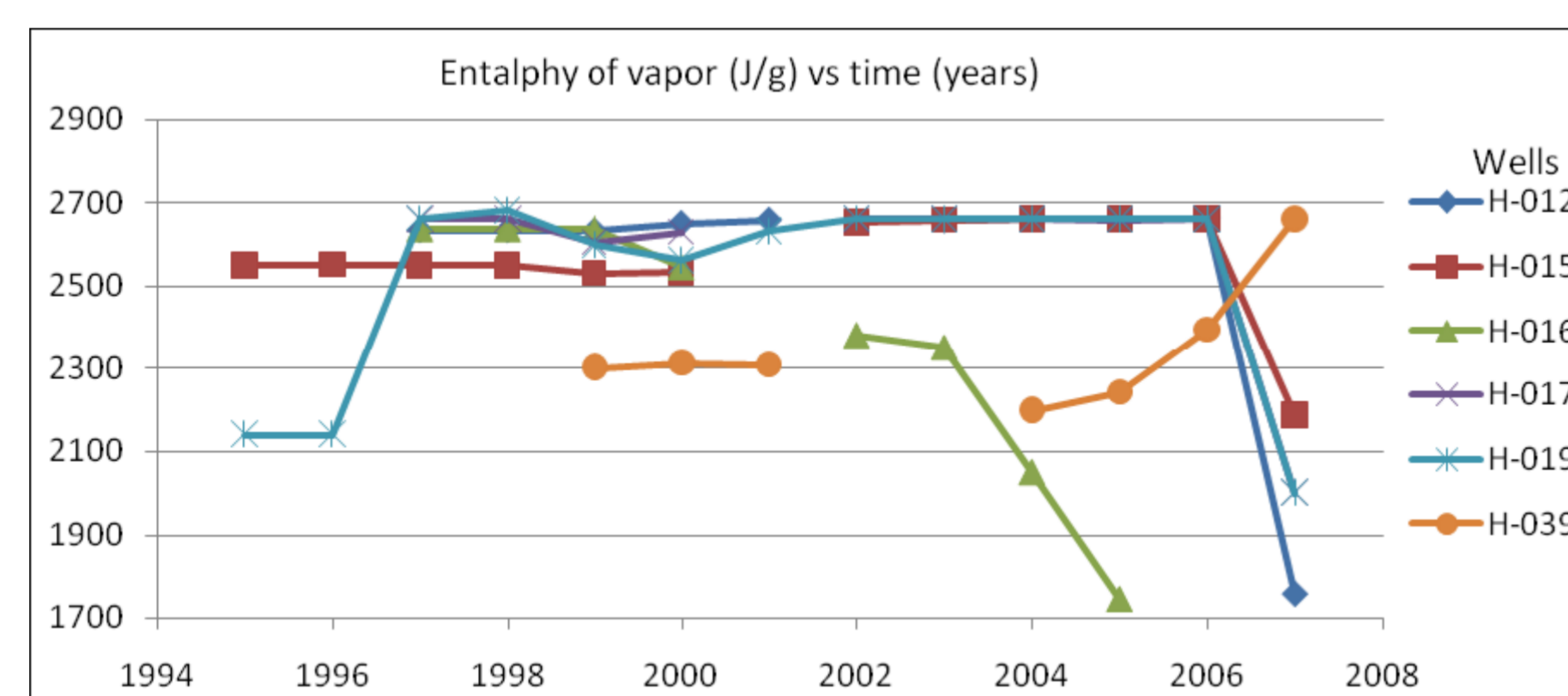


Figure 3: shows updated enthalpy values of steam reservoir against time

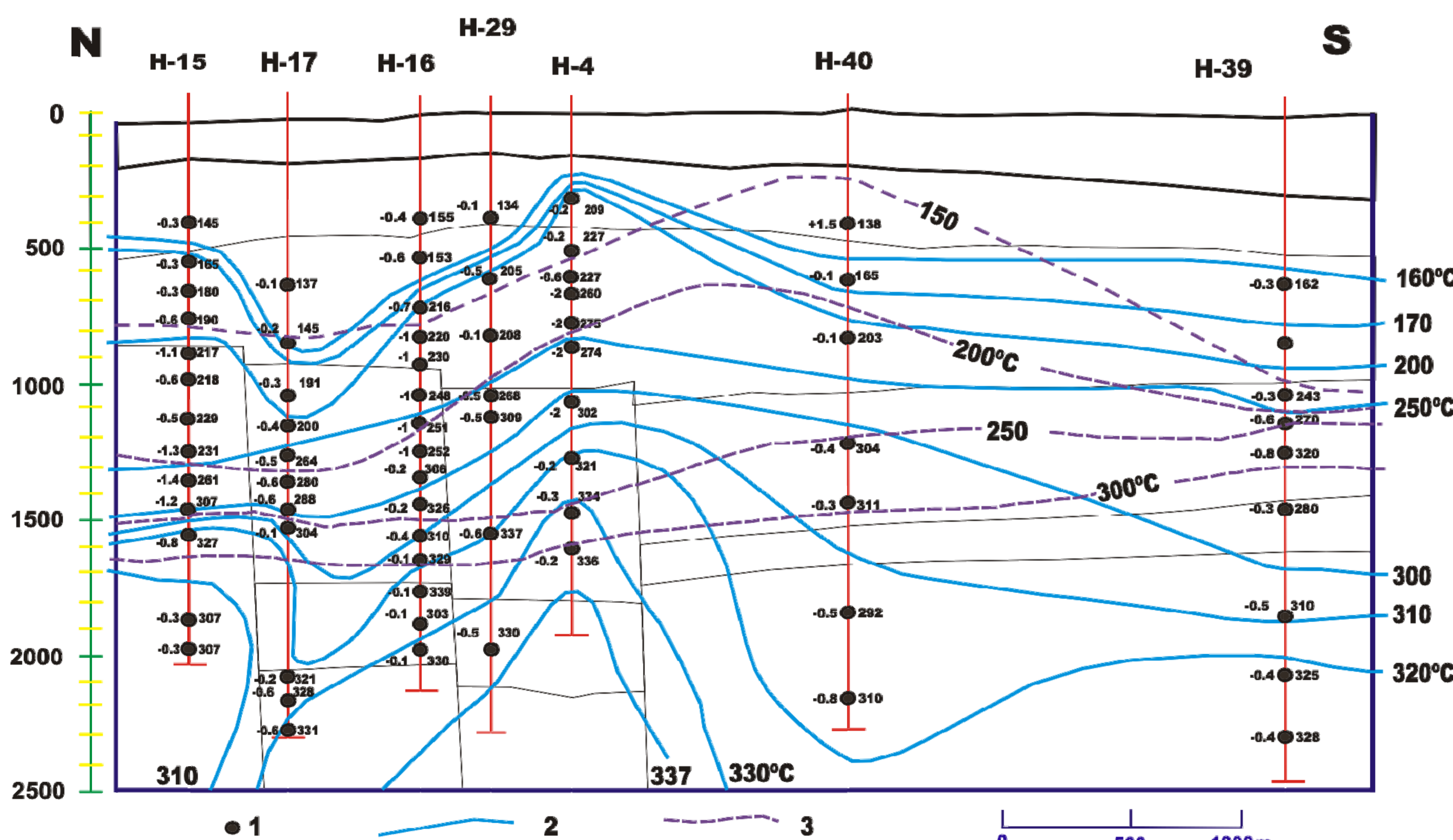


Figure 4: The continuing lines correspond to the isothermal average homogenization temperatures ( $T_h$  in  $^\circ\text{C}$ ). The dashed lines correspond to the stabilized temperatures ( $T_s$  in  $^\circ\text{C}$ ).

In the previous figure, are observed the average homogenization temperatures determined of the fluid inclusions study, resulting in the deepest zone  $T_h = 337^\circ\text{C}$  (Gonzalez Partida, 1985) and the current stabilized temperatures from wells having in the deepest zone  $T_s = 300^\circ\text{C}$  (Tello, 2005).

## GEOCHEMISTRY OF THE RESERVOIR

Based on updated data of chemical composition of the discharge fluids (water and gas) of a the same wells section (H-012, H-015, H-016, H-017, H-019, H-039) of the Los Humeros geothermal reservoir, also provided by the C.F.E. (2007), we elaborated the graphics of anions, cations and gases geoindicators as proposed by Giggenbach (1988) like that like Giggenbach and Goguel (1989), as shown in the next figures:

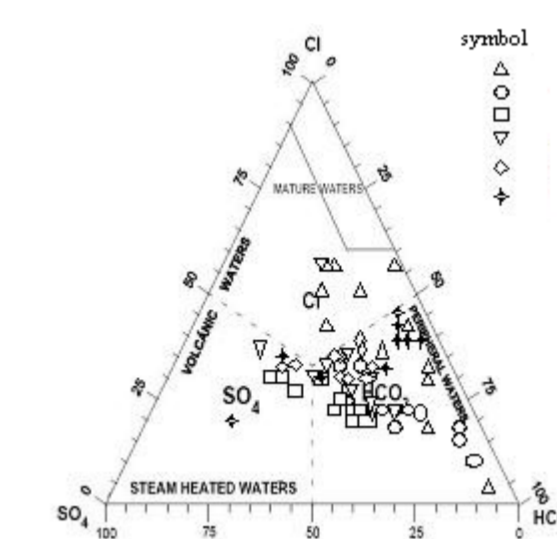


Figure 5: Ternary graphic of anions Cl-SO4-HCO3 to determine the balance of the reservoir waters (Giggenbach, 1989)

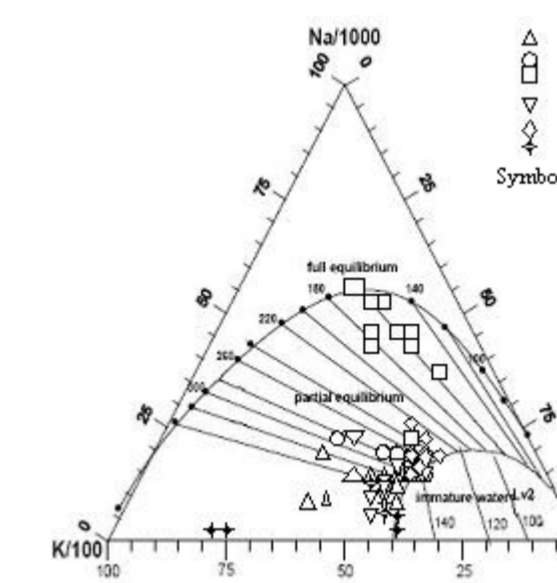


Figure 6: Ternary graphic of cations Na-K-Mg to determine the solute-mineral balance of the reservoir (Giggenbach, 1989)

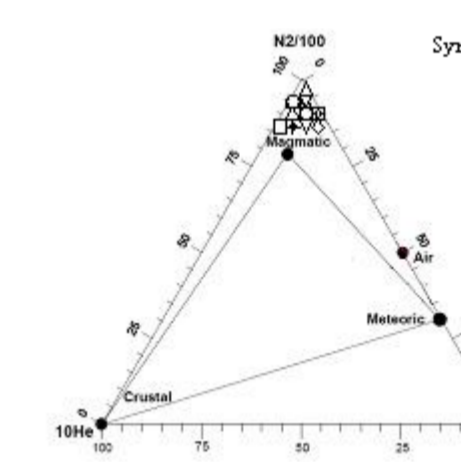


Figure 7: Ternary graphic of the gas N2-He-Ar to determine the origin of the reservoir gases (Giggenbach and Goguel, 1989).

In this way, we identified that in the Los Humeros geothermal reservoir exists evidence of two types (or two reservoirs, one shallow and one deep): one of meteoric water and the other of magmatic fluid (Giggenbach, 1988; Giggenbach and Goguel, 1989; Gonzalez Partida et al, 2001; Tello, 2005).

Also is possible to deduce that the geothermal reservoir is not in geochemical equilibrium between the fluids and minerals, thereof are in the process of achieving that balance, specific property of geothermal systems of recent origin. (Giggenbach, 1988; Giggenbach and Goguel, 1989; Gonzalez Partida et al, 2001; Tello, 2005).

## CONCLUSIONS

The Los Humeros geothermal field has a vapor dominated thermodynamic state. This fact can be accentuated by overexploitation (extraction of brine without sufficient recharge) of the reservoir. This thermodynamic state is compatible with the temperature profile of the reservoir.

In the Los Humeros geothermal deposit there is evidence of two types of fluids (or two reservoirs): meteoric waters and fluids of magmatic origin. The geothermal deposit is not in a state of geochemical equilibrium between the fluids and minerals, but these fluids and minerals are in process of reaching such state of geochemical equilibrium.

## ACKNOWLEDGMENTS

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