

Experiences on Geothermal Drilling in El Salvador

Manuel Monterrosa and Herbert Mayorga

Julio de 2007

Reykjavik, ENGINE WP 4

Contents

- History of geothermal drilling in El Salvador
- Rigs available
- Well targeting
- Casing programme
- Problems during drilling operations
- Well testing

Short history of geothermal drilling

- The well AH-1 was the first well drilled in El Salvador by Loffland Brothers during 1968
- The discharge test of well AH-1 was the kick off point for the geothermal development in El Salvador. This well is still connected to the power plant.
- Since AH-1, over 100 wells have been drilled in El Salvador contributing to the geothermal development



Discharge
Test AH-1



<i>Rig</i>	<i>Draw Work Horsepower</i>	<i>Static Capacity Ton.</i>	<i>Gross Capacity Ton.</i>	<i>Structure Capacity Ton.</i>
<i>Mass 6000</i>	1200	250	350	300
<i>Mass 4000</i>	1100	250	340	328
<i>Ideco H-525</i>	650	160	250	300

Rigs available PSB owned



Mass 6000, at Berlin



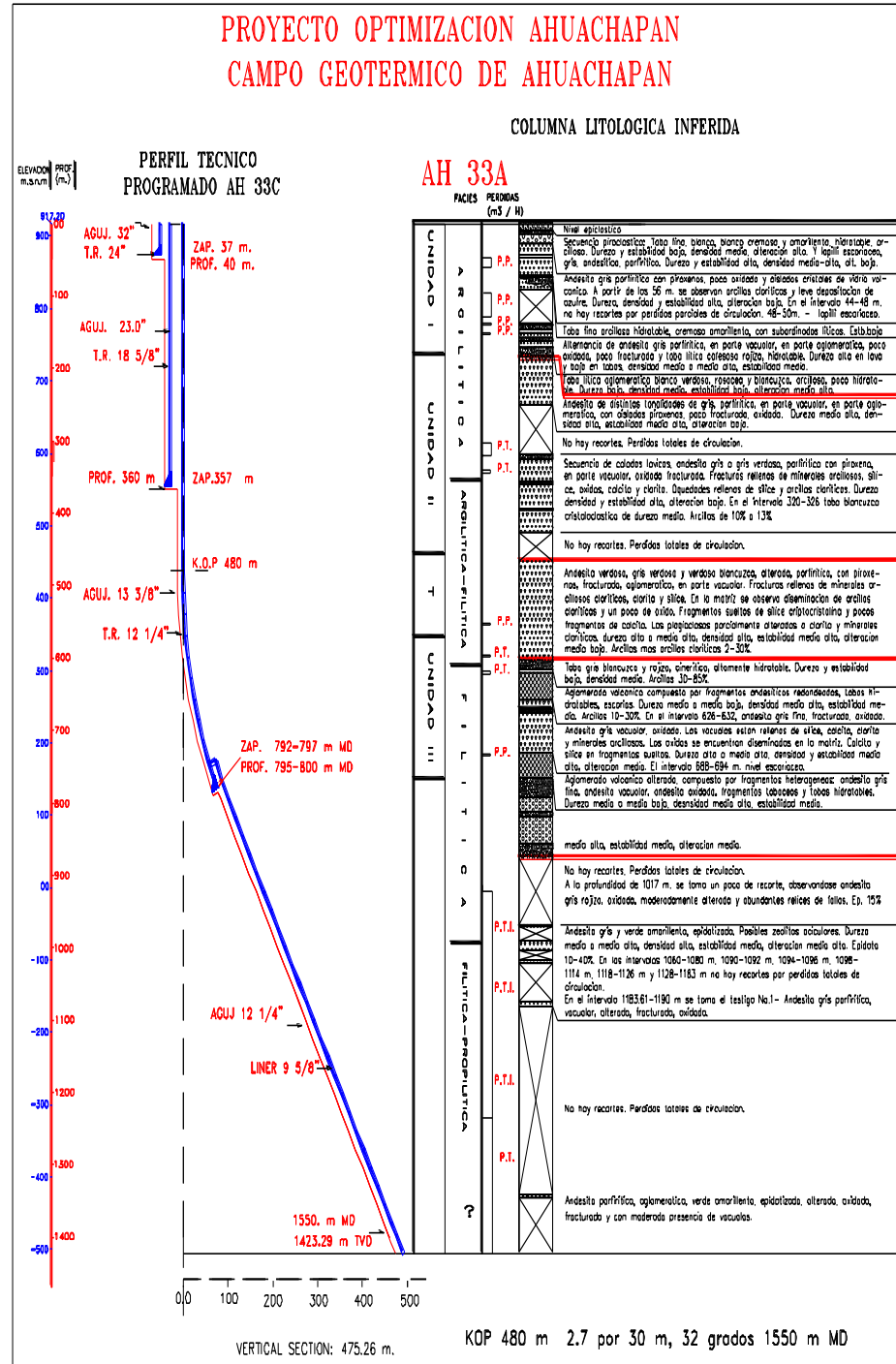
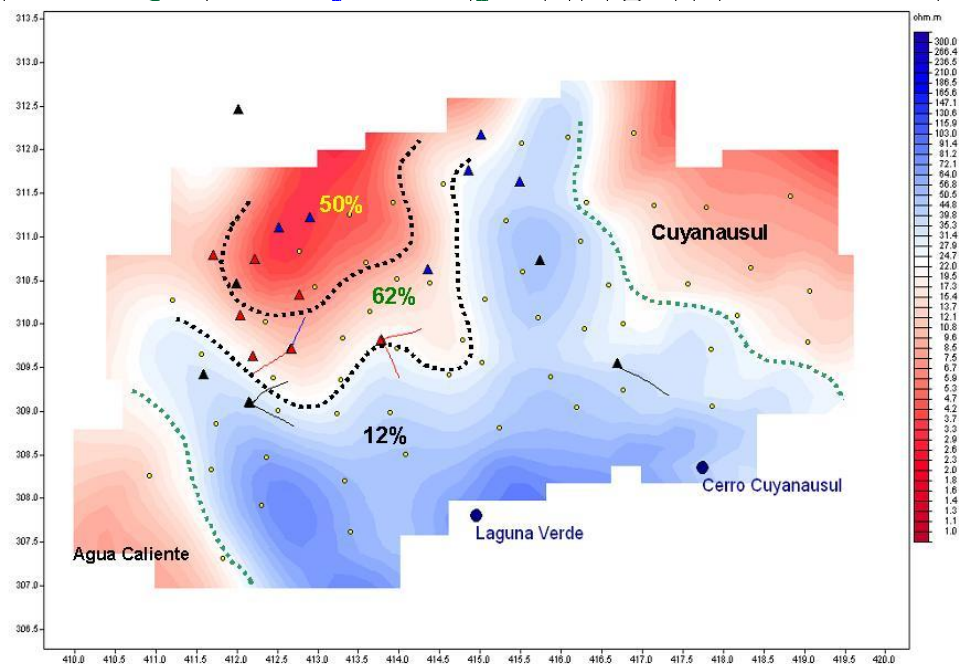
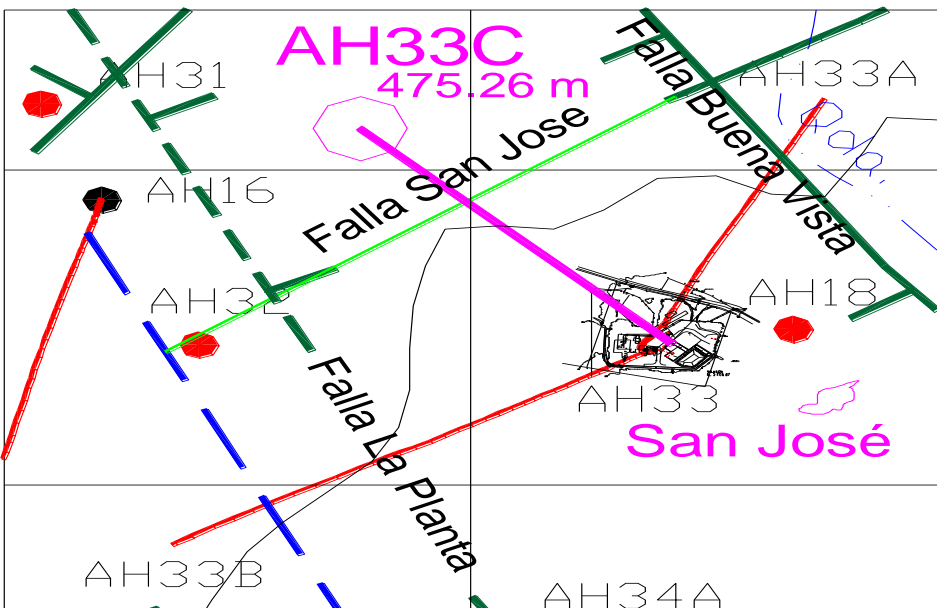
Mass 4000, at
Cuyanausul

Services companies available in El Salvador

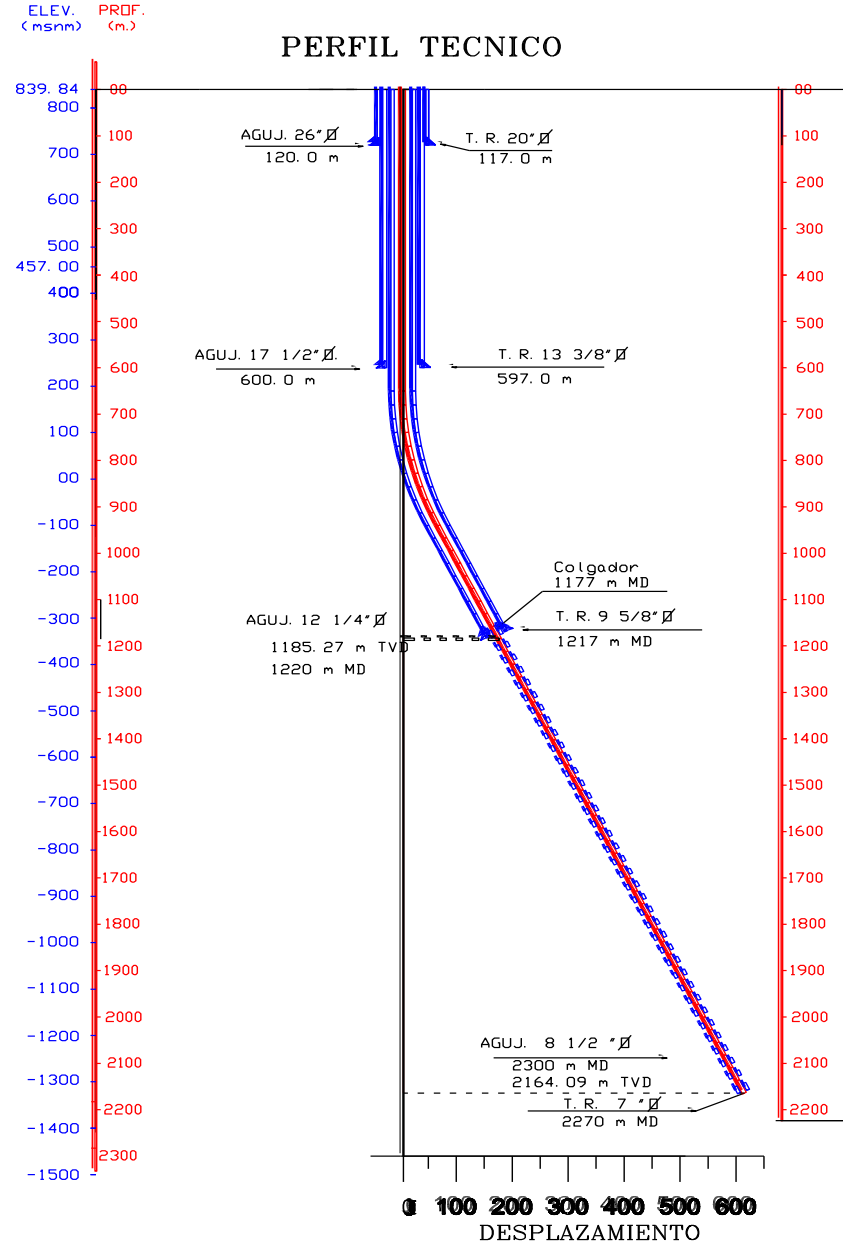
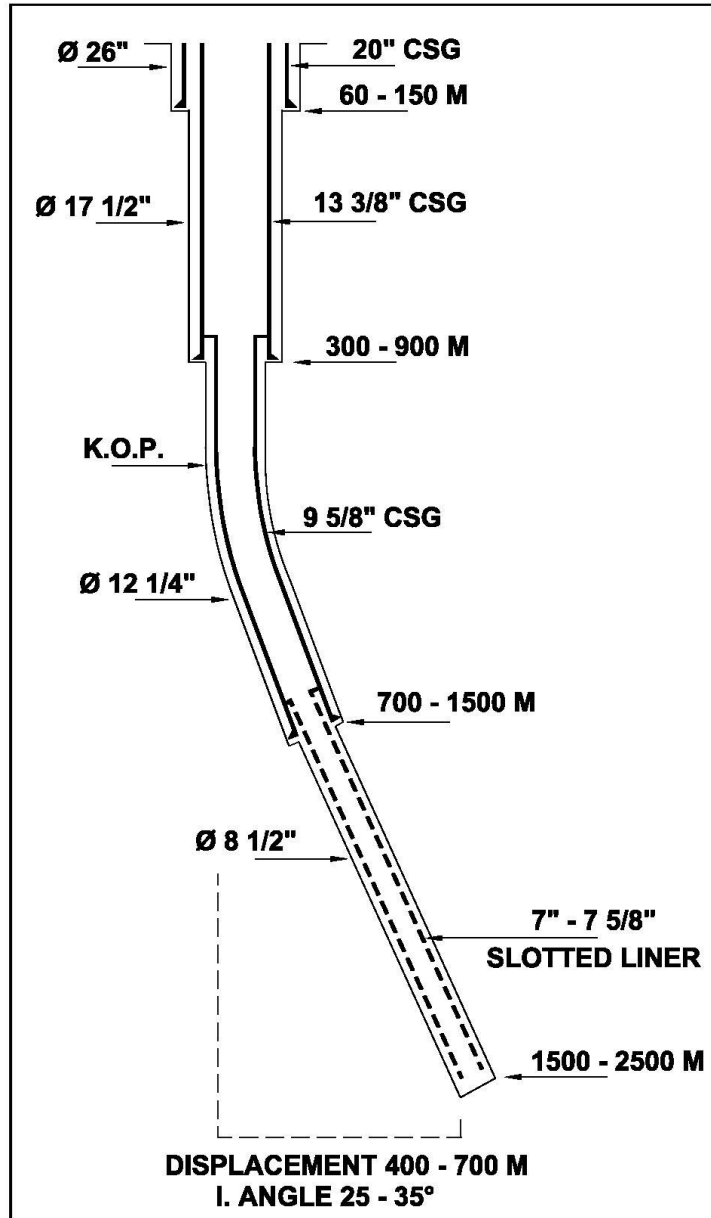
The services companies used in El Salvador are

- Cement services: BJ Services and Dowell
Schlumberger
- Directional Drilling: Anadrill and Baker Int.
- Well Logging (cementing, MWD, and caliper):
Schlumberger
- Air services Weatherford

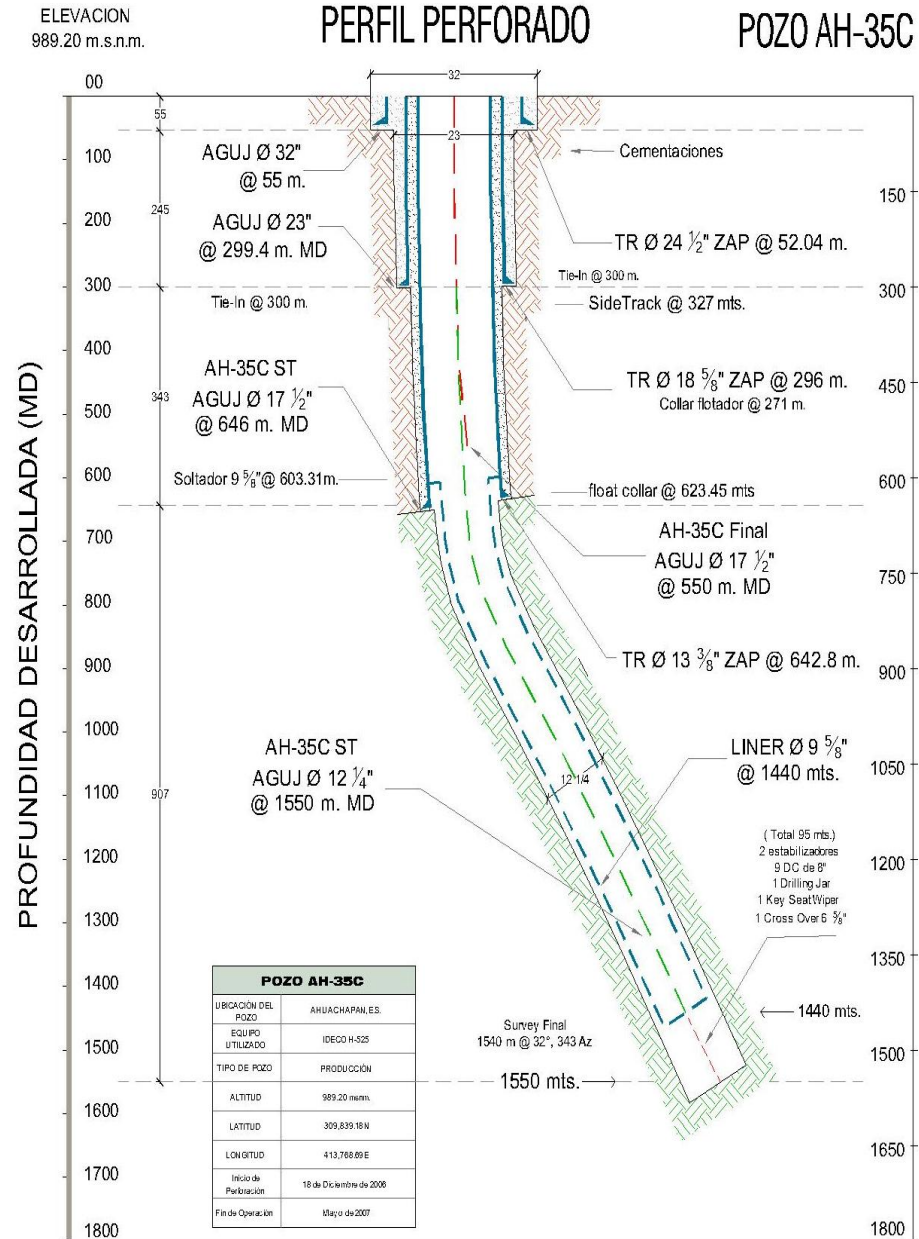
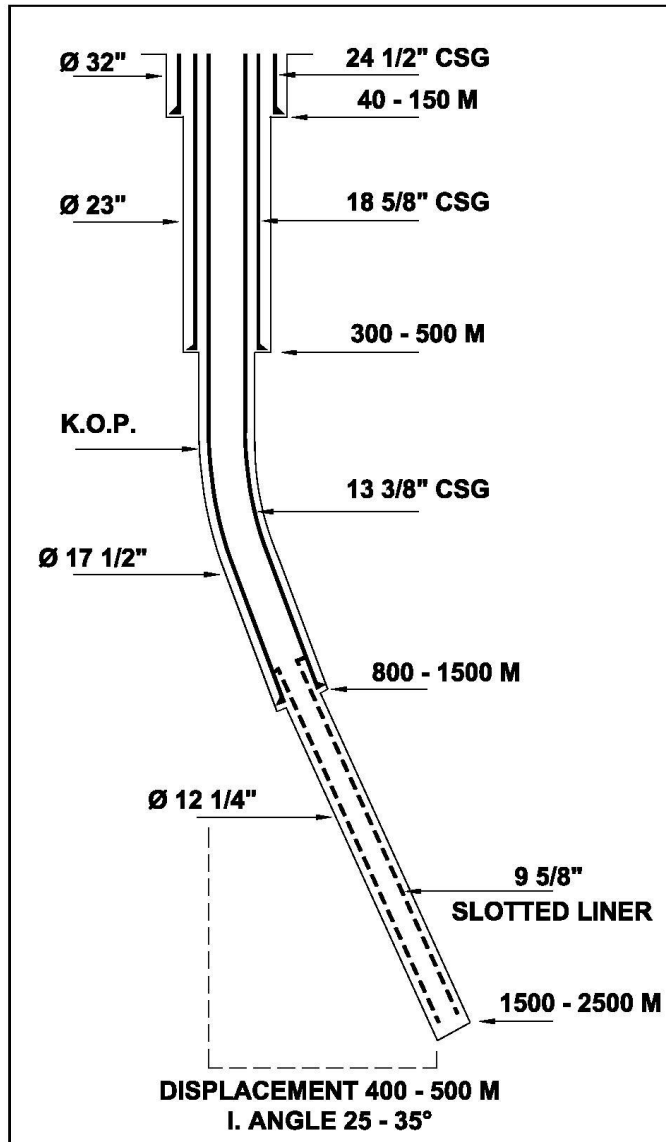
Well targeting



Conventional Well casing programme



Well known areas, well casing programme



Problems during drilling operations

Loss circulations

Loss circulation is happening when unexpected permeable zone is intersected, normally in shallows formations not the target area:

- Use of LCM materials, cement and concrete plugs.

In the medium or close to the reservoir (not in it).

- Cement plugs according to size of hole.
- Multiple plugs or changing consistency and viscosity of it.

Cementing casing

- A bad cementing job could cause casing collapse when the pipe is heating up and the well is discharging, normally it is observed when shallow permeable zone was intersected and the cement did not work satisfactory.
- The cement casing job could presents several problems, to prevent this, It is possible to use:
 - Use of light weight cement.
 - Use of tieback casing
 - Cementing in loss circulation at the bottom and cement from the upper part.

After cementing job CET/CBL must be necessary

Problems during drilling operations ..

Stuck and fish

The pipe stuck is happening when unstable formation is intersected and the mud is not working, in directional wells it could happen if there are large severity or “dog ledge”. This condition, will cause:

- Change or large deviation to the target.
- Breaking of drilling pipe for over stress.
- Fishing job could be necessary to recover the pipe.

To prevent pipe stuck

- Improve the use directional drilling system to prevent dog ledge conditions.
- Improve the mud flowrate and perhaps to use air to improve the cuttings recovering
- Use additives to lubricate the fluid.
- More frequently inspection test of the drilling pipe.

Blow out Control

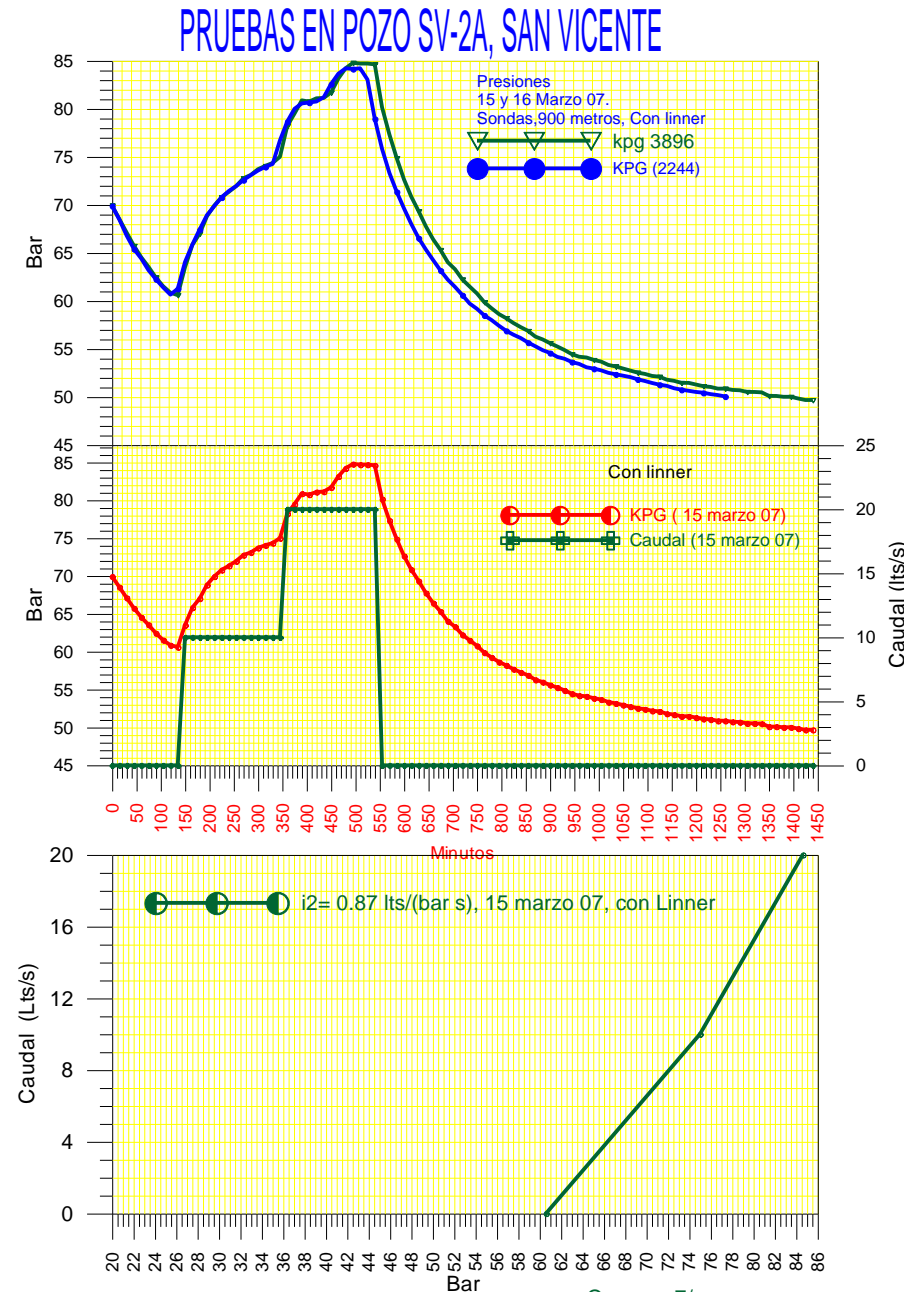
The blow out condition is happenig when steam are coming from the hole in unexpected way, in this case

- Use BOP is mandatory, BOP must be in good condition (tested)
- Good emergency procedures and personal trained for it.
- Survey equipment and drilling crew alert to those conditions.



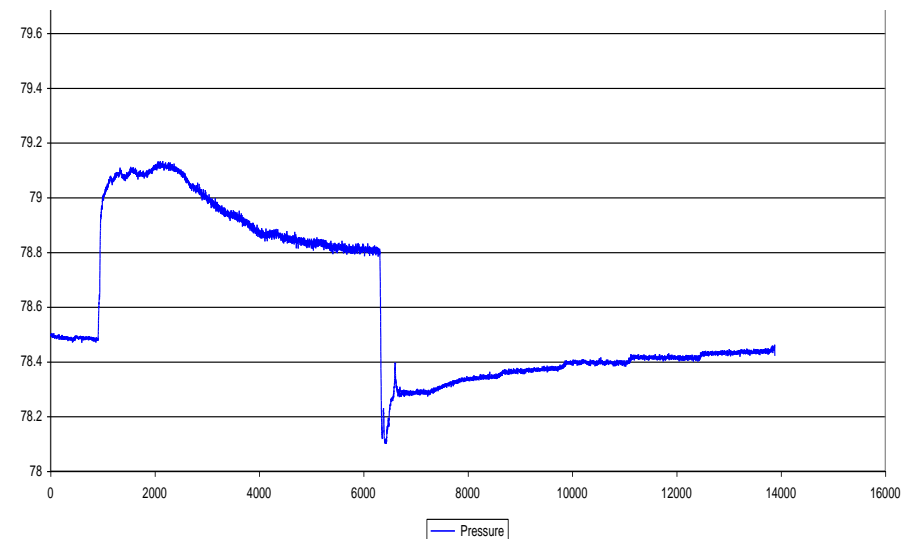
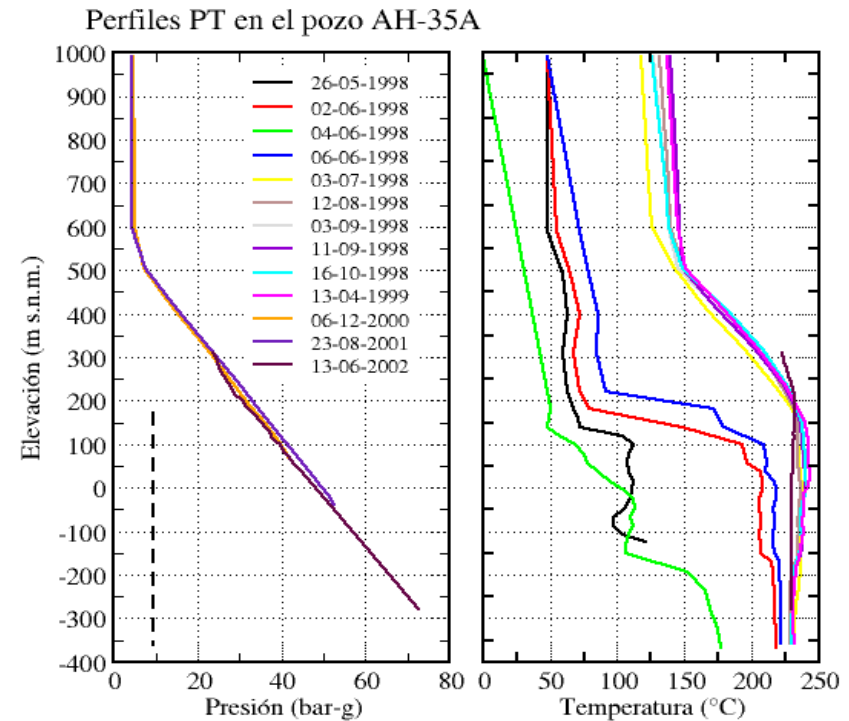
Well testing

- During drilling operation the well testing are:
 - Calipers, hole diameters
 - MWD (Measurement While Drilling) for directional data
 - CET/CBL cement bond logging
 - Water level and loss circulation data
 - Injectivity tests into the target zone
 - If available geophysical logging



Well completion

- When the drilling is finish and the target have been reached, at least the next tests could be done:
 - Final injectivity test
 - Warm up test including water level changes
 - Discharge test, when the thermodynamic condition indicate flowing conditions





CONGRATULATIONS, YOU
HAVE A GOOD WELL