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LaGeo S.A. de C.V.

WORKOVER OPERATIONS IN EL SALVADOR

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ABSTRACT

Work-over operation in the geothermal wells in El Salvador is one of the immediate solutions presented to maintain the production of the geothermal fields. This is usually undertaken when a well has a continuous operation for decades or for a longer time, or there is a degree of complexity to its damage during the mechanical completion or its own construction, and sometimes associated with the type of hydrothermal fluids that it possesses. This short study is based on the reports of two work-over operations carried out in Berlin and Ahuachapán geothermal wells between 2008 and 2010. Detailed experiences in different situations that have occurred during the development of each of the established programs before running the operations will be discussed.

1. INTRODUCTION

1.1 Work-over operations in wells

In recent years, work-over has been carried out in geothermal wells that have resulted from an initial analysis of the behaviour of the well, whether it is of characteristics of production or reinjection capacity. In producing wells, it is usually detected upon a decline in the production of their fluids; and in the case of reinjection wells, a decrease in the capacity to absorb fluids.

After the evaluation done by the generating company that owns the well, the drilling contractor is notified to do the job, and a series of meetings and discussions of the possible program of implementation for repair or mechanical intervention of the well operations are jointly undertaken. The meetings present the observations and analysis of the well that will be a candidate for work-over, which includes the history of the problem and the different solutions, until the program of execution is then proposed. Further discussions include the materials and tools needed for such implementation, where a final timetable of activities will be established and the program when the intervention operation will take place in the well. All of these activities are submitted to approval by the management of the generating company. Once the project has been approved, the company starts to hire the contractor, which will be responsible for the implementation of operations. The work is then executed with the direct supervision of the company that owns the well and as the operation goes underway, working meetings are carried out weekly or periodically on the site, with the aim of assessing the results obtained during the work-over operation.

2. WORKOVER IN WELL TR-18

2.1 Background

The well was drilled vertically in five stages in 2008, reaching a depth of 2660 meters (LaGeo, 2008). The first stage of 32" hole was drilled to a depth of 80 m with 24½ "casing and casing shoe at a depth of 75 m. The second stage of 23" diameter reached a depth of 543 m, with 18 $^{5}/_{8}$" casing and setting the casing shoe at 540 m." The third stage of 17 1/2" hole was drilled to a depth of 1,024 m, with casing of 13 $^{3}/_{8}$" up to a depth of 961 m. The fourth stage of 12 ¼" diameter was drilled to a depth of 1882 m with the casing of 9 $^{5}/_{8}$" anchored at a depth of 1819. The fifth stage of 8 ½" hole was drilled to a depth of 2660 m, but due to mechanical problems of entrapment (fishing) of a section of the drilling string in the well, the head of the fish was found at a depth of 2540 m. With this situation, the 7" slotted liner was set in the production casing of 9 $^{5}/_{8}$" to 1773 m, leaving casing shoe at 2536 m depth.

2.2 Objective of the intervention

The main objective is to remove the scale of calcite which is located at the interior of the casing of liner 9 $^{5}/_{8}$"Ø from 1459 m, through mechanical cleaning with the drilling string. In addition to mechanical cleaning operations, chemical stimulation of the well is programmed by injecting fluids through the drill pipe, located at different depths of the production zone of the well.

2.3 General information

Name of the well:	TR-18, geothermal field of Berlin.
Vertical depth:	2,660 m
Contractor:	Perforadora Santa Bárbara, S.A. de C.V.
Supervision:	Ingeniería de Perforación, LaGeo S.A. de C.V.

2.4 Drilling rig

The equipment to be used is the Massarenti 6000 of PSB S.A de C.V.

Draw-work:	Massarenti
Model:	Mass 6000
Series:	JM681, year 1981
Input power:	1350 HP

2.5 Workover operations

2.5.1 Mobilization and assembly of Massarenti 6000 rig

The MASSARENTI 6000 rig was brought from Nicaragua to the wellpad TR-18, with minimum equipment necessary to perform the work of mechanical intervention and chemical stimulation to the well.

During the assembly, the contractor, PSB, carried out maintenance and repair to some parts of the drilling rig, and changed the drilling cable to a completely new one.

2.5.2 Work-over operations

On October 26, 2008, the assembly of the drilling equipment was completed; and the problem with the pumping water system and the supply of diesel were overcome (PSB, 2008). With the satisfaction of the management of LaGeo the order was given to begin the intervention of the well at 13:45 hrs.

The well was cooled with the separated water at a constant flow of 11.7 li/sec. Initial pressure head was 5 bars and within 10 minutes of injection, the pressure dropped to zero. After two hours of pumping, the master valve was dismantled and immediately proceeded to the head mounting: Blowout preventer (BOP) of 13 5/8 "- 3000 (Annular and double rams) and assembly of the overflow pipe of 13 5/8".

The drill strings were then run down by section to verify the interior part of the casing of 13 $^{3}/_{8}$" with 12¼" bit Ø + bit sub + 6 $^{5}/_{8}$"x 4 ½" IF crossover++ 6 DC of 6½ "+ 4½" IF x 4 IF crossover+ 6 T.P. HW 5 "+ T.P. 5". The trip going down was free from casing 13 $^{3}/_{8}$" to 9 $^{5}/_{8}$" until 894 m depth, pulling the string with a 12 ¼" bit to the surface.

Connecting the drilling bit of 8 ½", the operation proceeded to the descent to the interior of the casing of 9 5/8", where at 1309 m depth, a resistance was encountered and continued to remove fouling up to 1500 m depth, without surface water circulation. The resistance upon the descent ranged from 2 to 5 Tons.

However, constant pumping pressure of separated water was maintained into the pit with a flowrate of 11.7 l/s. The input temperature of the separated water to the pit of the wellpad was 90°C and the temperature of injection into the well after passing through the cooling circuit was 50°C.

In order to get the scale sample for analysis, the string was recovered on the surface and a junk basket was connected on the bit of 8½ " + triple of D.C. from 6 1/2". Then it was lowered down to a depth of 1500 m up to 1510 m with resistance between 2 - 5 Tons and without return of water into the surface. The separated water flowed at a rate of 18 l/s and upon the connection of the drill pipe of 5", the flow was reduced to 11.7 l/s. The length of time of injection was 15 min.

The resistance disappeared at 1510 m depth and the descent of the drill string was free. The drill pipe was connected to reach the hanger of the 7" liner at 1773 m depth. The string was recovered on the surface and the 8½" bit+ junk basket was disconnected. However, it failed to retrieve the scale sample in the basket.

The next drill string was connected to verify the slotted liner 7" with 5 7/8" bit-mill+ 4 ¼"D.C. + 27 triples T.P. of 3 ½ " until it reached 2495 m depth. The Kelly was connected and proceeded to pump a flowrate of 12 li/sec of water reaching the depth of 2497 m (Figures 1 and 2).

After circulating at this depth for an hour to a flowrate of 16 li/sec, it proceeded to retrieve the string on the surface. During this recovery, all the drill pipes of 5" were found broken.

In order to carry out the operations of stimulation only with fresh water, the pit with the separated and fresh water near the wellpad was emptied until it allowed the suction of the pump from the pipe and tanks of the drilling rig, after the well was closed.

2.5.3 Chemical stimulation

Preparation of the mixture for the stimulation

Between the 1st and 3rd of November 2008, the preparation of the acid mixture was carried out to acidize the well.

At 17:00 hours of the 2nd of November, the cooling of the borehole was undertaken with a flowrate of 12 l/s for an hour. Drillpipe with diffuser tubing were lowered up to 2100 m depth. During the operation, a minimum flowrate of fresh water of 12 l/s was maintained, until the start of the acid stimulation.

Injection of the mixture in a single stage

Between the 3rd and 4th of November, the injection of the acid mixture took place into the well to a depth of 2100 m, where the procedure was as follows:

1. PSB pumped fresh water to 12 l/s by TF and 12 l/s by annular space during 4 hours.
2. BJ injected 120 m^3 of acid of 15% HCl, with a flow of 10 bpm. In addition PSB pumped freshwater by annular space 12 l/s.
3. BJ injected 80 m^3 of main mix to 10 bpm.
4. BJ pumped 300 m^3 of acid diluted at 8 bpm, while PSB moved 65 m^3 of fresh water through the annulus.
5. BJ injected 100 m^3 of water at a rate of 7 bpm and PSB maintained 12 l/s through annular space.
6. PSB reached the pumping of 350 m^3 volume of acid displacement at the rate of 15 l/s through the drillpipe and 12 l/s for annular space.

After completing the pumping of the volume of 350 m^3, it proceeded to rundown along the liner 7"Ø with the drill pipe to the depth of 2488.50 m. The Kelly was connected and proceeded to pump water, however, the drill pipe had been sealed and this would increase the pressure to 50 kg/cm^2. Fortunately, the problem was overcome and the drill pipe was disconnected.

2.5.4 Final operations

On the 5th of November, the blowout preventers were disassembled and placed in the same master valve 12" 3000 API of the well. On this same day at 14:00 hours, demobilization of the Massarenti 6000 drilling rig was undertaken, thus finishing the mechanical intervention and stimulation activities in well TR-18 in Berlín geothermal field.

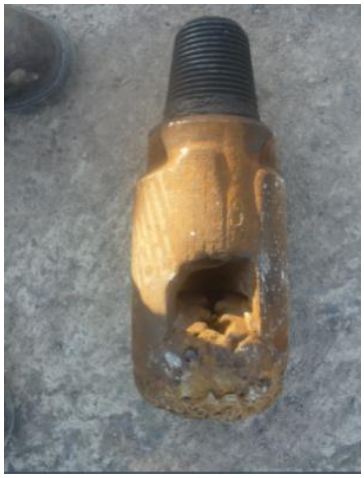

FIGURE 1: Side view of 5 7/8" bit-mill

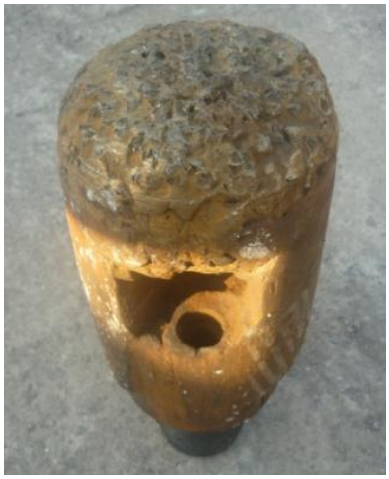

FIGURE 2: Top view of 5 7/8" bit-mill

3. WORKOVER OPERATIONS IN WELL AH-35B

3.1 Background

The drilling of the production well AH-35B was carried out between June and August 1998 to a total depth of 1555.55 m (PSB, 2010). The design of this well is a conventional completion of 4 stages: 26 ", 17 1/2", 12 1/4" and 8 ½", where the production casing shoe is at 728 m and the top of the hanger at

695 m. The slotted liner 7" has a total length of 836 m, with Hydril thread and a weight of 26 lb/foot. The liner shoe of 7" is located at 1,530 m depth (25.5 m above the drilled bottom).

On September 3, 2009, the well was scheduled to shut down, intending maintenance work to be carried out. At the start of the ascent of the camera of inhibition of calcite, after a meter of lift of the capillary, a resistance was encountered.

The tension of the wireline equipment was brought to full capacity, but the camera could not be extracted at the depth of 1,400 m. It showed that the chamber was trapped by the presence of deposits of calcite scale within the7" liner . The thickness and extension of the scaling deposit were unknown. A capillary tubing of ¼" outer diameter and 1/8" inner diameter holds the camera, which is made of Incoloy 825, of great hardness, in such a way that it cannot be milled easily.

3.2 Purpose of intervention

The aim of the intervention is to restore the capillary tube and camera of inhibition, trapped at the depth of 1,400 m, where a mechanical intervention of the well and chemical cleaning through the injection of fluids through the drill pipe for dissolution of any scaling of calcite in the interior of the well will be undertaken. It is expected to recover the production potential of the well which has declined with the passage of time.

3.3 General information

Name of the well:	AH-35B
Measured depth:	1555.55 m
Contractor:	Perforadora Santa Bárbara, S.A. de C.V.
Supervisión:	Ingeniería de Perforación LaGeo, S.A. de C.V.

3.4 Drilling rig

The equipment used is Ideco H-525D of PSB S.A de C.V.

Drawwork:	Ideco
Model:	H-525
Series:	D, year 1979
Input power:	650 HP

3.5 Workover operations

3.5.1 Mobilization of the drilling rig

On October 22, 2009, the mobilization of the drilling "IDECO H-525-D equipment began from the wellpad of TR-14 (in Berlín) to the wellpad of AH-35B, located in Tacubita, municipality of Ahuachapán, Department of Ahuachapán.

On October 29, 2009, the mobilization was completed and on November 14, 2009 work-over operations started by first pumping water (from the pit) to the well to cool it down.

3.5.2 Workover operations

The cooling of the well started with the Cementation Unit PSB Freemyer with a minimum flowrate and continued to pump water through annular space with the pump equipment at 8 l/s (3.02 bbl/min).
On November 15, 2009, preparation for the installation of blowout preventer with 13⅝ 3000 API was carried out; pumping was increased to a flowrate of 15 lps (900 lpm) and later prepared the extraction of the capillary tubing of the trapped camera at 1400 m depth, without damaging it.

Then the Master Valve 10" ANSI 600 (equivalent to 11" API 2000) was raised and the capillary tubing was pulled under the instructions of LaGeo staff. The master valve was removed and so was the capillary tubing inside the preventer Double Rams 13⅝ API 3000 (Shaffer) and the spherical preventer 13⅝ API 3000 (Annular Hydril).

On November 16, 2009, the assembly of the float line was completed, while constant pumping through the annular space at 8 l/s (480 l/pm) continued. The well was opened in observation and preparation for the acid mix to inject into the well by the staff of LaGeo.

The well had mounted the blowout preventer while pumping a constant rate of water through annular space with 8 lps (480 lpm) flow during 9.5 hours. Waste water in the pool was recovered and the preparation of the mixture of acid to pump into the well was completed.

Pressure lines were tested to 5000 psi, and pumping of acid was performed. A meeting for safety procedures was also conducted; PSB undertook the acidification process by pumping into the well through the annular space, using the cementation unit Freemyer for 7 hours.

Subsequently, personal of LaGeo tried to pull the capillary tubing with its unit of wireline, applying tension of up 320 kgf, which was not enough to release the capillary, so it was decided to perform the test of tension with the drilling rig's winch, applying a tension of 1000 kgf.

The capillary was left with this tension for 2 hours and with a tension of 680-700 kgf, the capillary tubing was released (Figure 3). However, after recovering approximately 30 m on surface, the capillary tubing broke and only 119 m of the tubing were recovered.

The fishing spear was then connected to the 3½-inch drill pipe to reach the depth of 304 m, maintaining constant pumping through annular space at flow 15 l/s (900 app.) (Figure 4). Fishing operation with the spear was immediately carried out to 304 m and recovered 222 m of capillary tubing.

FIGURE 3: Tension indicator for the capillary

FIGURE 4: 3 ½" spears

After releasing the capillary tubing, the spear was dropped to a depth of 600 m, applying rotation (7 laps in total); and during the recovery, a resistance of 30 to 40 Tons between 600 m and 478 m depths was observed, but the spear was trapped for 1 hour applying tension of 45 Tons until it was recovered again at 458 m depth, where another resistance of up to 50 Tons (40 Tons on the weight of the drillstring) was noted, without releasing the tool.

The work was carried out for two hours with negative result; so it was decided to pump hydrochloric acid to clean possible slag and subsequent implementation of the lubricant. After the preparation, PSB pumped acid mixture of $5m^3$ of volume through TP within 3½ ", using the cementation unit Freemyer.

It should be noted that about 4 hours after applying the acid, the well was forced to discharge for 5 minutes.

On November 19, 2009, with 50 Tons applied on the string, 10 m³ of pure lubricant with flowrate of 14.5 l/s through the annular space was pumped, and tension and compression manoeuvres began to release the tool. Then it continued pumping pure fluid lubricant at 8 l/s until completing 20 m³, where it accomplished to recover 3 ½-inch drillpipes; later the fluid lubricant was diluted and pumping was continued through annular space at a rate of 8 l/s for 5 hours until the spear was recovered, up to 343 m depth with 30 Tons total tension, liberating the tool from that point.

The spear was immediately recovered to the surface with low resistance (maximum 5 Ton on the weight of the TP in some sections); and a lot of capillary tubing wrapped around the spear was observed (Figures 5 and 6).

It was noted that during the recovery process, the capillary tubing was found compacted forming a cylinder where at the internal part was the fishing spear. The external diameter was the same as the casing of the 9⅝", and the height of the cylinder was the length of the spear. The total recovered capillary tubing was 260 m (data provided by the staff of wireline after weighing the capillary tubing).

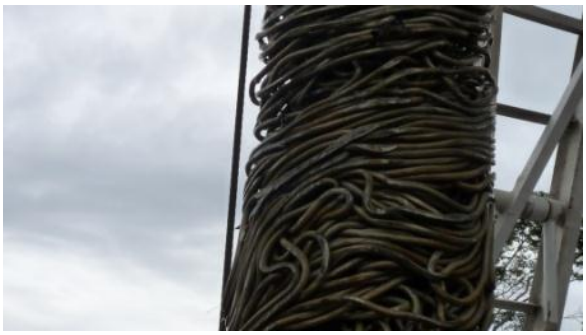

FIGURE 5: Capillary compacted and wrapped

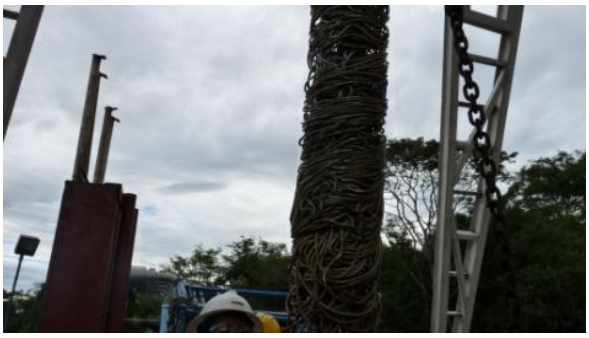

FIGURE 6: Height of cylinder around two meters

Repairs on the hooks of the harpoon were carried out after the fishing process.

The well flowed through the interior of the pipe of 3½ ", and proceeded to install the Kelly Valve and increased the pumping, which lasted approximately for 8 minutes. 35 m³ of batch lubricant was prepared, which was diluted by pumping a total volume of 100 m³.

The harpoon at the 520 m depth continued down to 550 m depth, with connection of triple TP 3½" premium. Fishing operation at this depth freely recovered the spear to the surface observing some capillary tubing around it, where at the bottom part came with some tension.

The cable stuck in the spear was cut and the tensed part was set through a disk with groove to the height of the rotary table. The capillary tubing was recovered using the drilling rig winch, reaching a tension of 120 kgf, which could indicate a possibility that the camera was recovered.

A total of 389 m of cable was recovered: 41 m in the spear and 348 m coiled in the truck; indicating a recovery of a total 1000 m of the capillary tubing (Figures 7 and 8).

The harpoon was then dropped to 650 m depth up to 668-801 m depths; however, the fishing operation was unsuccessful as the recovery of the harpoon to the surface was negative. It was later recovered at 1000 m depth, with the Kelly connected, however it was observed that 60 m of capillary tubing were trapped in the harpoon.

FIGURE 7: Partial recovery of capillary

FIGURE 8: Arrangement of fixers for capillary recovery

On November 23, 2009, the descent of the spear with a combined TP of 3½"and 5" at 801 m depth was carried out with the Kelly connected; however applying rotation, it also gave negative result. The method was repeated reaching 801 m depth with 48 m of capillary tubing stuck in the spear upon its ascent to the surface; and again at 1270 m depth combined with TP 3½-inch and 5", with negative results.

The spear was lowered down again to 1290 m and 1340 m depths recovering 30 and 46 m of capillary tubing, respectively. At 1340 m depth, with the Kelly valve connected and stationary at that depth and the preventer open, the water was pumped at 8 l/s. The well was in observation for 12.5 hours with the spear at 1340 m and constant pumping through annular space at a rate of 8 lps. Meanwhile, LaGeo staff began to prepare 30 m^3 of aqueous solution of HCl to 15%. The Kelly Valve was disconnected and the spear continued descending until 1375 m depth and stayed for 1.75 hours for final preparations of the injection of acid. PSB proceeded to do the pumping of acid using the cementation unit Freemyer.

After dismantling the set-up for acidification, the pumping of water was re-established through annular space at a constant rate of 8 l/s, with the Kelly connected and the manoeuvre of fishing at 1377 m depth encountered a resistance of 10 Tons. The recovery of the spear was repeated pumping water through TP with triple 3, extracting 15 m of capillary tubing. The spear was dropped until 1390 m, again with resistance of up to 20 Ton. The fishing operation was carried out with much torque in the rotary table. The Kelly was then disconnected, same as the TP 5 "(to get triple full) and freely recovered the harpoon to the surface; extracting 10 m of capillary tube.

The spear was sent to 1390 m depth, without TP of 5" but with the Kelly connected and at 1392 m depth, another resistance was encountered of between 8 to 10 Tons again. A weight of 12 Tons was applied at 1393 m depth, where fishing operation was carried out with much torque in the rotary table. The same procedure was undertaken to get the spear up to the surface, extracting 7.5 m of capillary tubing. Again, the harpoon was dropped to 1390 m depth, and at 1393 m depth a resistance of between 8 to 10 Tons was observed. Applying 12 Tons of weight down to 1393.5 m depth with much torque (returning completely to its original position); the harpoon was recovered to the surface extracting 11 m of capillary tubing, which were found in four pieces. As the harpoon reached the surface, 1m of capillary tubing was extracted.

Immediately the spear was placed again reaching 741 m depth. The harpoon was found at 1393.5 m depth and continued descending, applying up to 22 Tons down to 1394.0 m depth. Fishing operation was carried out with much torque in the rotary table recovering the harpoon to the surface and extracting 22 m of capillary tubing compacted with a diameter equivalent to the interior part of the slotted liner.

The harpoon was dropped at this time at 1394.5 m depth, with between 18 to 20 Tons resistance; and began to recover it again to the surface, but with negative results. It was subsequently dropped to 1394.5 m depth, with 20 Tons compression applied and was down to 1395.1 m depth; at this point, recovery of the harpoon to 1223 m began.

On November 30, 2009, the recovery of the harpoon to the surface was completed with a negative result. Downhole measurement for Temperature and Pressure surveys was undertaken at 1300 m, maintaining constant pumping to 16 l/s. The flow of water was increased to 40 l/s to carry out injectivity test with the equipment K-10 at 1000 m depth for 3 hours, where later it was dropped to 16 l/s down to 1300 m depth and then recovered the K-10 surface.

The spear was lowered down again and at 482 m depth, the well presented manifestation to discharge. Observation of the well was done for 30 minutes and then the harpoon continued down to the depth of 1395 m, with pipes of 3½"(ϕ)and 5"(ϕ).

Again, at 1395 m, the harpoon was recovered to the surface but with negative result. While waiting for the new instruction, continuous pumping of water through annular space at a rate of 15 l/s was carried out.

Encountering resistance at 1391 m depth, the mill equipment of 5 ¼“ diameter was applied with 11 rpm rotation and ½ to 1 Tons of weight, at this time, a new manifestation of gas from the well was observed in the mill. The resistance was lowered at 1391 m until 1394.78 m depths. Initial water flow rate pumped into the well was 15 l/s and 8 l/s flow for the annular space.

On December 2, 2009, the resistance continued with the mill equipment from 1394.78 m to 1395.0 m using Rotary at 11 rpm and 2 Tons of weight and pumping water through the interior of the pipe at a rate of 15 l/s and 8 l/s for the annular space; recovering it to the surface, with wear at the bottom and lateral parts. During the recovery operations, pumping was re-established through annular space at 15 l/s.

After the preparation of aqueous HCl mixture was completed, the first stage of the chemical stimulation using the cementation unit FREEMYER started by pumping water through annular space at a rate of 15 lps (6 bpm); Meanwhile the drill pipes were recovered to locate the bottom at 985 m depth, and then proceeded to carry out the second stage of acidification.

At the start of the pumping of acid, manifestation of the well was observed where preventer ring on the pipe 5"(ϕ)was closed. PSB finished 40 m³ of water injection of condensates as Postflush with flow of 12 barrels/minute (bpm), through the interior of the TPF. Later PSB began to inject 200 m³ of water of condensate at 6 bpm through the annular space and 6 bpm through the interior of the TP, using the pump equipment for displacement of the mixture.

Finishing the 200 m³ of water injection of condensate, the recovery of the TPF started at 541 m by pumping water through annular space at 15 l/s at the zone where manifestation of the well was observed at 985 m.

At the depth of 456 m, another manifestation of the well was observed, which was controlled by pumping of water through the interior of the TP and the annular space. After 2 hours, dynamic logging of T and P for 1 hour was undertaken using element K-10.

Subsequently, the pumping was increased through annular space up to 40 l/s for injectivity test with K-10 anchored at 1000 m depth. After 3 hours, the flow of water was regulated through annular space to 15.5 l/s.

On December 4, 2009, the element of measurement K-10 was still at 1000 m in the diffuser pipe, with constant pumping of water through annular space to 15.5 lps. After 0.25 hours recovery of the diffuser and K-10 to the surface began, finishing the operation after 3.75 hours.

After disconnecting the diffuser and the K-10, the "Jet" 3½-inch(ϕ) (Figures 9 and 10) was connected, and observed manifestation of the well at 142 m upon its descent. The annular preventer was closed, with the Kelly Valve and Kelly connected while pumping through the interior part of the drillstring until the emanation of gas and water was controlled.

FIGURE 9: Tube diffuser of 3 ½”

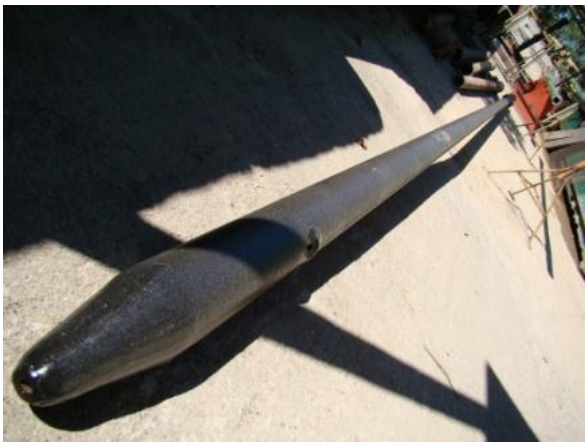

FIGURE 10: Pipe jet of 3 ½”

As the "Jet" went down to 1394.5 m depth, operation of tension and compression (up to 10 Tons) was carried out trying to pass the obstruction, reaching only 1395.0 m depth. After 3 hours of manoeuvres with negative result, it was circulated for 30 minutes at 1395 m and then recovered the "Jet" to the surface. At this time, water pumping at 8 l/s through annular space and the interior of the pipes to 15 l/s was undertaken

The well was left open for observation and water was pumped at a rate of 15 lps during 2.5 hours. Meanwhile, the spear of 2" ϕ x 1.50 m was welded to the interior part of the pipe of 3½" d (ϕ), with a total length of 2.20 m. The tip of the harpoon was lowered to 1394.5 m depth and water was pumped through annular space with volume of 15 l/s without overcoming obstruction.

After 5 hours, it proceeded to assemble a triple DC 4¾ "(ϕ), connected the new spear and began the descent of the equipment. At 540 m depth, violent manifestation of the well was observed at the interior of the pipe and annular space; so water was pumped through the interior part of the pipe to control the well.

The descent of the spear continued up to 1395.0 m depth but the recovery of the harpoon to the surface was negative. While waiting for the instruction, water was pumped through annular space at 16 l/s.

The operation of the descent of the harpoon continued up to 656 m and 1114 m depths and again the well presented manifestations and to control it, water was pumped through the interior part of the TP. The recovery of the harpoon to surface was negative.

On December 7, 2009, the descent of the Core bit 5" (ϕ) finished at 1394.5 m depth, water circulated for 30 minutes with flow of 15.5 l/s (928 lpm) and pumping through space at 8 l/s. However, it observed surface wear and on the interior part of the pipe 5" ϕ.

It repeated to lower down at 1414.93 m depth but there was little progress and on the recovery at the surface, very compacted capillary tubing inside the tube 5"ϕ was found. Replacing with a new core

bit, it started to lower it down until 1525 m depth and water was circulated for 30 minutes with a flow of 15.5 lps (928 lpm). Immediately, the recovery of the crown began and at 258 m depth and the capillary tube was estimated to have a length of 52 m.

On December 9, 2009, the same procedure was done with little progress and at 1525.0 m depth, a resistance was again encountered.

FIGURE 11: Crown millof 5" x 3 ½"

FIGURE 12: Joint of Crown mill of 5" x 3 ½"

After circulation of water for 30 minutes with flow of 15.5 l/s (928 app.), the recovery of the core bit to the surface began.

On December 10, 2009, milling was undertaken, but the well presented manifestation at 1152 m depth. The annular preventer was connected, the Kelly connected and pumping was carried out through the interior part of the pipe.

Once controlled, Lageo began to do the measurement for dynamic P and T up to 1524 m depth with flowrate of 20 l/s for 1.75 hours. After the measurement was completed, the system of preventers was dismantled and the Master Valve 10" ANSI 600 (equivalent to 11 "API 2000) on spool 13⅝ API 3000 X 11" API 2000 expansion was installed, maintaining the pumping condition at 15 l/s. The total recovered capillary was 1,303 m.

The work of intervention in well AH-35B was completed at 16: 30 on December 11, 2009. A new master valve was replaced as there was leakage in the valve previously installed on December 13, 2009.

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PSB, 2008: *Daily reports of well TR-18 workover, Berlín geothermal field.*

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