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Silica Deposition in High Enthalpy Well: A Phenomenon Encountered in Palinpinon Geothermal Field, Southern Negros, Philippines

Joeny Q. Bermejo and Kenneth Jireh Taboco

Energy Development Corporation, Southern Negros Geothermal Production Field, Ticala, Valencia, Philippines

bermejo.jq@energy.com.ph, taboco.kg@energy.com.ph

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ABSTRACT

Mineral deposition along the wellbore can cause output decline of geothermal production wells. A well in Sector B sector was initially discharging two-phase fluid, however, due to pressure drawdown, it eventually dried up in 2010. A steep decline in output was observed in well and the suspected cause is wellbore deposition based on downhole survey. Mineral deposits composed mostly of amorphous silica were also present along the branchline during the inspection of the two-phase line in 2012. Geochemical modelling and evaluation were conducted and the results showed that a transient increase in the brine loading of the reinjection (RI) wells from a nearby sector is the likely source of the silica rich fluid that flashed and deposited as it reaches the wellbore. Previous naphthalene disulfonate (NDS) tracer study conducted also confirmed the reservoir connection between well and the reinjection (RI) well.

1. INTRODUCTION

Well D is a vertical production well drilled in 1978 in Sector B and has an initial output of 8 MWe. It has 38% water fraction and enthalpy of 1990 KJ/kg. But water flow gradually dropped since the start of its commercial utilization in 1994. Eventually, in 2010 steam flow dropped and blockage were tagged along the wellbore and this prompted the work over and acidizing in 2010. Well D gained 3 MWe of steam output after the workover and acidizing, however, months after, the discharge of Well D the discharge turned pure steam (Figure 1). All the other wells where Well D is located are high enthalpy wells with dry steam discharge. The absence of mineral rich brine (i.e. dry wells) typically equates to lesser risk of wellbore scaling. Mineral deposition in Well D is very unlikely because of the absence of brine

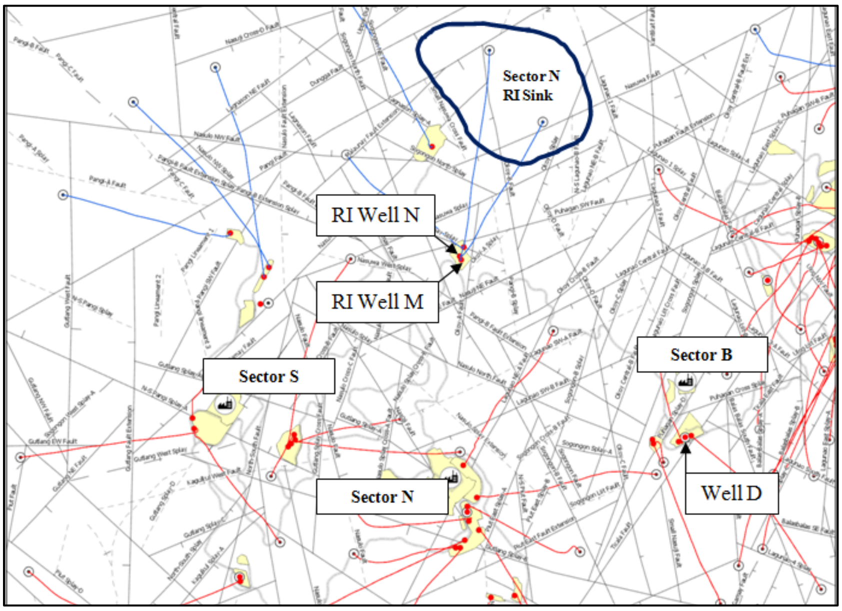

Figure 1: Sectoral Map Showing Location of Well D

2. MODELLING THE MINERAL DEPOSITION IN WELL D

The Fortran computer program, SOLVEQ-XPT and CHIM-XPT by Reed, Spycher and Palandri, were used to model the mineral scaling in Well D. SOLVEQ has the capability to compute equilibria at any specified pressure and temperature. CHIM-XPT, however, can model complex processes such as cooling of hydrothermal solutions, reaction of solutions with rock, fluid-fluid mixing, gas titrations, boiling, adiabatic decompression, condensation, and evaporation (Reed, et al., 2012).

The brine reinjected to the reservoir will be reheated in the formation because of the stored heat in the reservoir rock. In this model, it is assumed that this brine will equilibrate with reservoir temperature of 261 degrees Celsius. After being reheated, the brine was flashed again to the surface to simulate the brine form RI Well N mixing with the original reservoir fluid of Well D and discharged back to the surface. Modelling result showed that the flashing of the heated brine to the surface will precipitate amorphous silica starting at 182 degrees Celsius (Figure 2).

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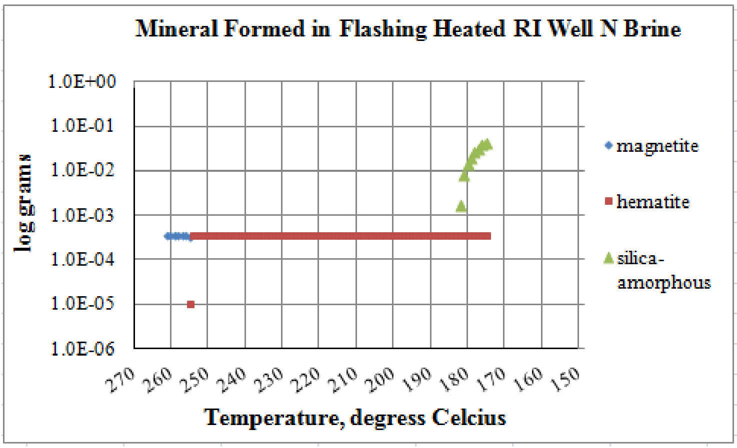

Figure 2: Modelling Result of Flashing the Heated Brine form RI Well N to the Surface

3.0 EVALUATING THE EFFECT OF BRINE RETURNS FROM SECTOR N

Despite discharging pure steam, in 2012, Well D experienced a steep decline in steam flow. The decline rate was ~1MWe per year, the highest decline rate monitored in Well D (Figure 3). This occurred two months after the termination of the simultaneous discharge of production wells from the nearby sector, Sector N (Lagare et al., 2012). Normal operation of Sector N uses only three production wells, while during the simultaneous discharge test, all eight wells were discharged. During the simultaneous discharge test of all production wells in Sector N, the total reinjection loading in its two reinjection well exceeded the 100 kg/s limit. Based on the naphthalene disulfonate (NDS) tracer injection study conducted in 2005, in one of the reinjection wells in Sector N, it was established that there is a connection between the RI sink of Sector N and Well D. Well D has 6.63% tracer recovery from RI Well N. Greater than 100 kg/s loading will cause cooling of nearby production wells including Well D (Maturgo et. al., 2010).

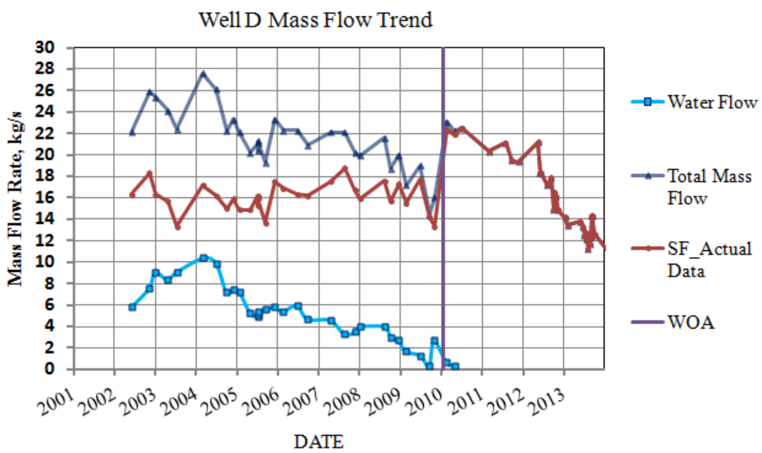

Figure3: Well D Mass Flow Trend Showing Steep Decline in Output in 2012

Geochemical evaluation of Well D showed an indication of RI returns due to the decrease in CO2td. Subsequently, CO2td increased indicating boiling process that occurred after the termination of the simultaneous discharge (Figure 4).

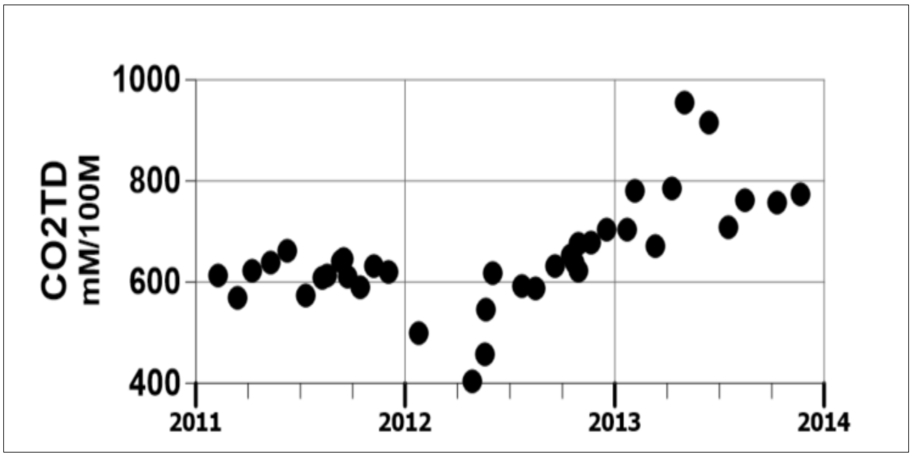

Figure 4: CO2td Trend of Well D from 2011 to 2014

Go-devil survey of Well D also indicated likely deposition along the wellbore of Well D (Lagare et al., 2012). This indicates that wellbore deposition could have likely re-occurred since the workover in 2010 (Figure 3)

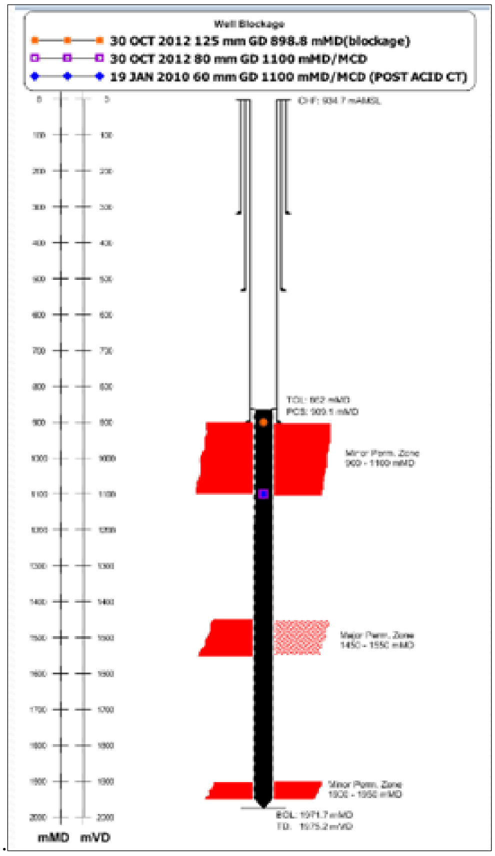

Figure 3: Blockage Indication Along the Wellbore of Well D Based on Go-Devil Survey

During the inspection of the branchline in 2012, thick mineral deposits were found covering the walls of the pipeline (Figure 4). Based on petrological analysis, these dark gray, glassy, very hard and multi layered deposits were 75% amorphous silica and 25% impurities.

Figure 4: Well D Branchline with Thick Mineral Deposits

This kind of deposition can be formed when a brine is supersaturated with these minerals. The brine component of Well D could be in mist form that it was not measured in conventional flow measurement technologies like Tracer Flow Test (TFT) and Jame's Lip pressure method (JLPM). This brine in mist form was also impossible to separate and be collected using Webre separator.

4. CONCLUSION

Mineral deposition in high enthalpy wells with pure steam discharge is very unlikely. However, the presence of brine in mist form can likely cause mineral deposition along the wellbore or branchline. Well D discharge fluid initially has brine component that was supersaturated with calcite and amorphous silica that caused blockage along the wellbore. But when the discharge fluid of Well D turned dry, it was not expected that mineral blockage would likely re-occur. The well in the sector where Well D is located are all high enthalpy wells discharging dry steam. This sector also does not have any reinjection well. NDS tracer injection in one of the reinjection wells in Sector N established the reinjection flow path from the reinjection sink of Sector N towards Well D. During the increase of reinjection loading in Sector N, the effect of reinjection returns was manifested with the decrease of CO2td of Well D indicating brine intrusion. During this period the decline rate was a high as 1 MWe/year, the highest monitored for Well D. Sudden decline in output was attributed likely to mineral deposition along the wellbore as indicated by blockage survey and the deposits observed along the branchline.

Modelling result of the flashing of the heated re-injected brine in RI Well N showed that it will precipitate amorphous silica starting at 182 degrees Celcius. Due to the overloading of reinjection fluid in Sector N, where RI Well N is located, it caused brine carry-over in Well D. This brine could be present in mist form and flashed along the wellbore of Well D causing mineral deposition. This eventually led to the output decline of Well D.

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